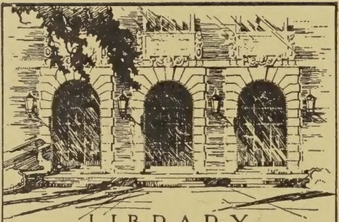

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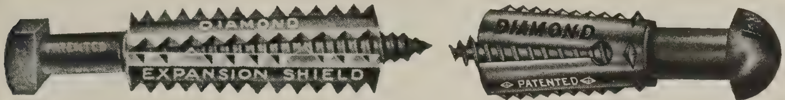

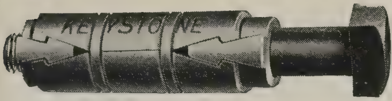

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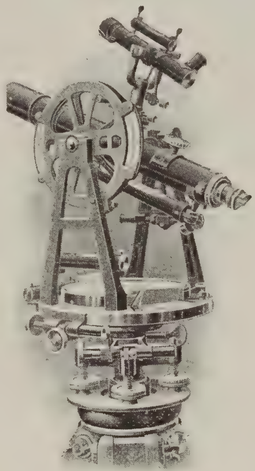

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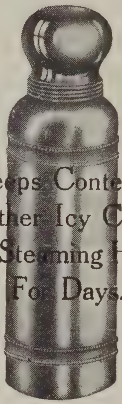

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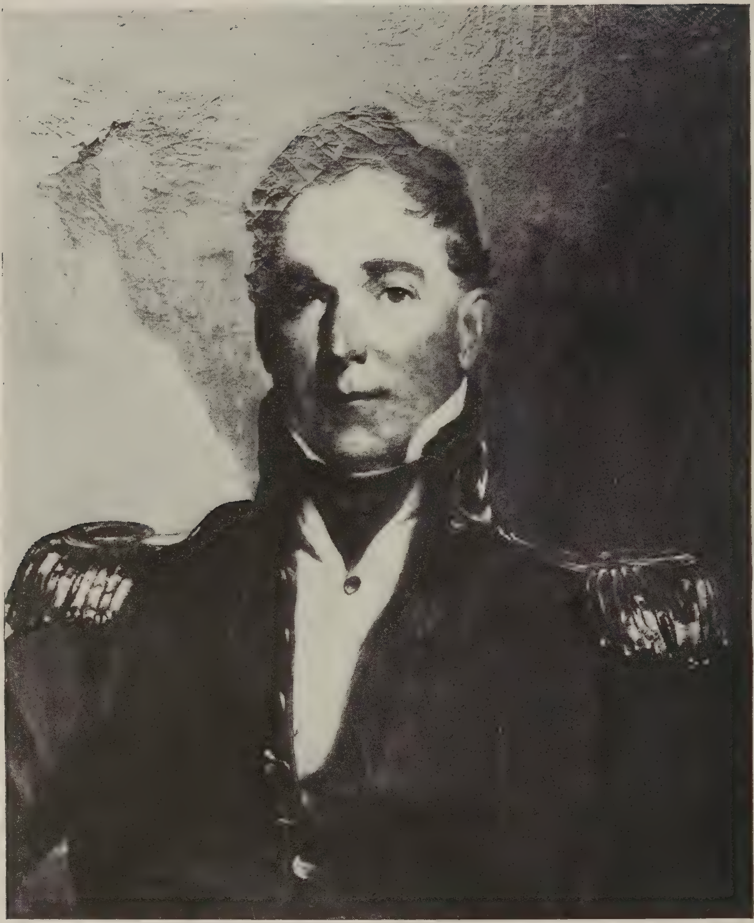

Bvt. Brig. Gen. Charles Gratiot
CHIEF ENGINEER, UNITED STATES ARMY
1828-1838
BORN 1788—DIED 1855

FIELD SEARCHLIGHTS

BY

Mr. EARL WHEELER[*]

AND

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Readers of foreign technical and military journals during the last few years must have noticed how much attention is being given abroad to the development of the electrical searchlight for field uses. The necessity of the searchlight as an adjunct of permanent defenses, both for seacoast and land defense, has long been recognized. The desirability of using it in a mobile form for various military purposes with a field army has become apparent with the appreciation of the importance of night operations, especially since the Russo-Japanese War. The possibility of designing a field searchlight equipment which in power, mobility, and reliability, shall be satisfactory for field purposes is evidenced by the numerous types of these equipments now employed in foreign armies, and has come about through the mechanical improvements in the construction of the electrical projector and of small prime movers, notably of the internal combustion type.

The uses of searchlights with a mobile field army and in siege operations are not radically different, and may be summarized as follows:

Defensive—

1. To illuminate points over which the attackers must advance, as defiles, so as to bring them under fire at the earliest possible moment and for observing the effect of fire.

2. To illuminate the attacking forces with dispersed beams at the closer stages of the attack.

3. By lighting distant areas, for embarrassing the movements of larger bodies of hostile troops, and disclosing the transportation of supplies, as well as work in progress on the line of investment.

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4. To impede the work of hostile searchlights by forming lighted zones.
5. For the convenience of working parties of all kinds.
6. For assisting in searching for the wounded after an engagement.
7. For signalling.

Offensive—

1. To prevent the defence from improving entrenchments and obstacles under cover of darkness.
2. To light up definite artillery targets, such as redoubts.
3. To assist the attacking columns by lighting up rough ground, obstacles, etc.
4. To assist the attacking columns to keep their direction by lighting that part of the defender's line selected for the assault.
5. To prevent offensive movements and assist in repelling the counter-attack.
6. For illumination for working parties of all kinds.
7. For impeding the work of hostile lights by forming lighted zones.
8. For searching for the wounded.
9. For signalling.

There are, of course, a great many disadvantages attendant on the use of searchlights, especially in the field. The outfits are expensive, easily disabled, they require a highly trained personnel for their operation, their effect is to a very large extent dependent on the state of the atmosphere and the configuration of the ground, they make heavy demands on transportation if drawn by animal traction, and require a constant fuel supply and are dependent on the state of the roads if of the automobile type.

The field of the searchlight is practically limited to position warfare—to sieges and to the attack and defense of positions held by field armies which have been strengthened for the purpose of a stubborn defense.

In regard to the oft-heard criticism that searchlights disclose the position of the force using them, the following extract is quoted from a work on "The Tactical Utilization of Electric Searchlights," by Captain Aggermann of the Austrian army, translated by First Lieut. Ulysses S. Grant, Corps of Engineers.

> The objection often made that searchlights assist the enemy in orienting himself is largely the result of practice in time of peace. Of course, a searchlight on unfavorable terrain will not have any great success, as it will be seen by the maneuvering troops, while the latter will not be noticed by the observer. But on favorable prepared terrain this is all different, and the observer can see also; then when operations are in earnest it will not go quite so well with the illuminated enemy. The position of the defender's works must be very well known to the attacker, especially when he is planning night operations, before the searchlights can betray the location. Moreover, if, in his advance, he comes within reach of the beam, he will be rather confused than

oriented, and will be exposed to the effective fire of the defence. An enemy who is not within the beam may even be led astray by intelligent changes in the positions of the projectors or by the introduction of reserve lights.

Before proceeding to a description of the field searchlight outfits in our Army, a brief mention of the work done in this line by foreign armies may be of interest. The English have a field searchlight company, at present only tentatively organized. It consists of six "power units" divided into three sections of two power units per section. Each power unit consists of a projector wagon and a generator wagon. The former is a limbered wagon drawn by a 4-horse team and carries the projector, cable drums, spare parts, etc. The latter is drawn by six horses and carries the engine, generator, fuel, water, etc. Each power unit has a working detachment of six non-commissioned officers and sappers, who ride on the projector and generator wagons.

In addition to its two larger projectors, which are 24 or 36 inches in diameter, each section has three or four smaller (12 inch) lights, to be carried on one or two carriages, which are not at present decided on. On a war footing the British searchlight company, as tentatively organized, will be composed of 5 officers and 168 non-commissioned officers and privates, with 134 horses and 29 vehicles. They consider that there should be one searchlight company per division. The excessive demand on personnel, animals, and vehicles, under this organization, should be noted. To obviate it, the English have been recently experimenting at their maneuvers with automobile sets.

The Germans have experimented extensively with searchlights mounted on motor vehicles with very satisfactory results, and have decided to introduce them for field purposes.

The Russians have recently taken up the question of field searchlight equipment. According to the "Kriegstechnische Zeitschrift" it is intended to equip the general staff of each corps and each division of infantry with one 75 cm. projector. Each regiment of infantry and each independent battalion shall receive, for the present, one, and later, several, 35 cm. projectors. Each artillery brigade and each cavalry division shall have one 75 cm. projector, which is to be transported like a horsed field piece. The organization of an independent searchlight corps is being worked out, and provisional regulations for the tactical uses of the searchlights are being drawn up.

The French have completed within the past year a searchlight

equipment which comprises a projector of about 90 cm. diameter, mounted on a specially designed motor car chassis. The car carries five men in addition to the projector, generator, etc. The projector is mounted on small rubber-tired wheels and is carried on the rear platform of the car, which is driven by an 30-horsepower motor and can attain a speed of 15 miles per hour. It is said to be adapted for travelling across country, and to be superior in point of speed and compactness to any previous plant of this kind. One of these searchlight cars is illustrated in Fig. 1.

The Austrians have searchlight sections consisting of a 90 cm. projector mounted on a 4-horse truck, engine and generator on a 6-horse truck and a 4-horse supply wagon. The personnel of each section includes the light commander, 1 engineer with helper, 1 projector operator with helper, 1 observer, 3 telephone operators, 1 control operator, 1 wagon-master, and 7 drivers. They also have 35 cm. searchlight sections organized on similar lines.

The Spanish used field searchlights very effectively in the Melilla campaign of 1909 against the Moors. These lights were assigned to the balloon company and comprised three 90 cm. projectors with steam-engine driven generators, one 90 cm. projector with petrol motor, one 60 cm. and one 45 cm. projector with steam engines and twelve 40 cm. projectors of the oxy-acetylene type. General Don Jose Marva, of the Spanish engineers, says that on this, the first occasion on which searchlights were used in the field in the Spanish army, they met with brilliant success and that experience has justified their employment.

The Japanese equipment used in the Russo-Japanese War is described by Maj. J. E. Kuhn, Corps of Engineers, in his report on the siege of Port Arthur. They used two trucks, one carrying the 90 cm. electrically controlled projector, the other the oil-motor driven generator, switchboard, radiator, etc.

The Italians recognized at an early date the utility of field searchlights, and had regularly organized trains at least as early as 1900. They adopted steam as their motive power, and used 36-inch and 24-inch projectors in their heavy and light trains, respectively. Their vehicles were excessively heavy, the engine and generator wagon of the heavy train weighing about 9,000 pounds. In their 1909 maneuvers the Italians experimented with a motor car carrying a dynamo and hauling a 2-wheel limber carrying the projector. The projector was said to have a limiting range of 2,500 meters.

The Dutch outfit consists of a projector wagon and a self-pro-

pelled dynamo vehicle with benzine motor. The projector is of the 60 cm. size and is hand controlled.

In this country the first portable searchlight outfit to be devised was the steam-engine operated plant which was purchased about 1900 and is now at Fort Leavenworth, Kans. This set was too cumbersome to be adapted for field work, but sufficient experience was had with it to indicate the desirability of an outfit which could be readily transported. Another steam set with an 18-inch projector was designed for the Signal Corps, but was too heavy for field transportation. More recently the Navy has purchased some sets, for use at advanced bases, which are more satisfactory. They have 30-inch projectors, the current for which is supplied by a 2-cylinder gasoline engine driving a 7-kilowatt D. C. generator. The generator truck, carrying engine, generator, switchboard, radiator, gasoline and water tanks, and projector rheostats, weighs 4,040 pounds with tanks empty. The gasoline tank has a capacity of 21 gallons and the water tank of 12 gallons. The searchlight truck carries a 30-inch hand-controlled projector, cable reel with 1,000 feet of twin conductor, 75,000 cm.; tool box, spare parts, etc., and weighs 3,720 pounds.

Fig. 1. French Automobile Searchlight Equipment

The Coast Artillery has also experimented with portable equip-

ments. Their plants were constructed along the same general lines as those of the Navy, but had a 3-cylinder instead of a 2-cylinder engine and a device for elevating the light. The generator truck weighed 5,930 pounds, and the searchlight truck 5,400 pounds.

The most recent portable outfits designed in this country are the auto searchlight truck and the Field Artillery set, both designed under the supervision of and purchased by the Engineer Department. The former is so different from anything which has been heretofore developed, either in this country or abroad, that a detailed description of its development will be of interest.

AUTO-SEARCHLIGHT CAR

In developing special apparatus for Army uses one must look toward the existing commercial apparatus for types and ideas. Such was the case in developing an automobile searchlight equipment for our Army. The field, to say the least, was very limited, and none of the touring car manufacturers wanted to undertake special apparatus in their overcrowded factories, and, furthermore, would not undertake the production of any car when cross-country, muddy road guarantees were demanded. The development therefore tended toward heavy trucks. Of these, the choice lay between electric and gasoline motors. Since the accepted type of high-power searchlight required the supply of direct current at constant voltage, it seemed simple enough to conclude that a gasoline-electric truck would do the work. In theory the answer was very simple indeed, but when it came to the point of manufacturing such an outfit it was very difficult to obtain any electric-truck manufacturer who would undertake the problem.

About this time (winter of 1907) the writer (Wheeler) happened to run across an article in one of the technical magazines describing a gasoline electric-truck which was built especially for the work of hauling large lenses to the Carnegie Solar Observatory in California. This truck was built by the Couple-Gear Freight-Wheel Company of Grand Rapids, Mich., and was a 4-wheel drive, 4-wheel steer "Couple-Gear" electric-truck depending on a gasoline engine (automobile type) generating set for its current. This, then, was a plan to work upon, as it was confidently believed that a truck that could cope with the severe conditions of load and roadbed described would be eminently satisfactory for field purposes in the Army. Roughly speaking, the tests of the present machine (auto-searchlight) have proven that this belief was justified.

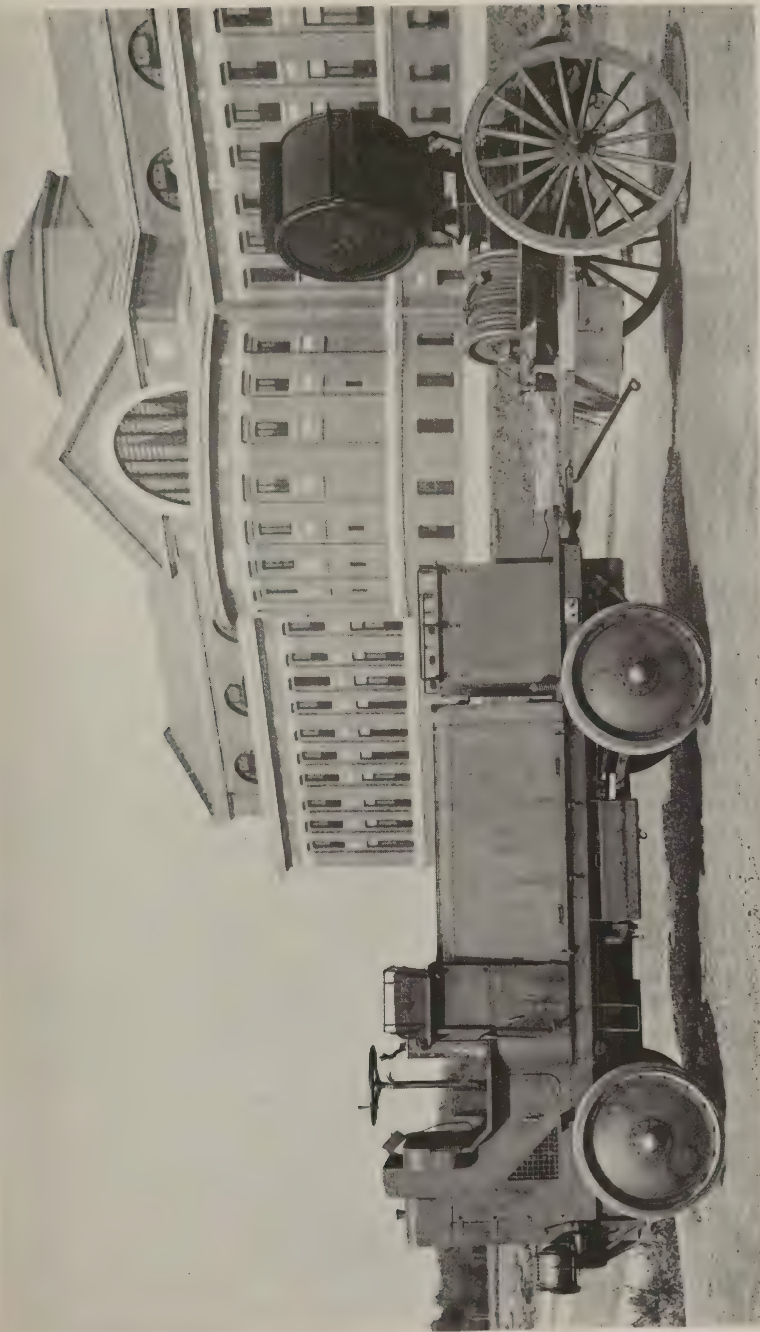


Fig. 2. Auto-searchlight with Trailer

The auto-searchlight consists of two units, the automobile, hereafter called the car, and the searchlight trailer. This outfit is shown in train in Fig. 2. The car is a specially designed and built "Couple-Gear" truck upon which is mounted a 15-kilowatt gasoline-engine generating set, the engine being of the semi-automobile type. The searchlight trailer consists of a standard Field Artillery caisson upon which is mounted a spring-supported platform, three-point suspension, carrying a 30-inch General Electric white metal mirror, electric-control searchlight with 500 feet each of supply and controller cable. Its weight, complete, is 4,400 pounds.

THE CAR

The driving system consists of four "Couple-Gear" wheels, as shown in Figs. 3 and 4. Each wheel motor is of the direct-current series railway type, of 3 horsepower capacity, normal rating, and designed for normal operation on 85 volts, although they have satisfactorily operated without any perceptible sparking on 150 volts. The motor is of the pancake type and bi-polar. The back frame is a part of the inside support which is connected to the rigid axle through the steering knuckle. The motor armature has a shaft running through it, on each end of which is a bearing which is part of the motor casing, and a bevel pinion. One pinion engages in a circular bevel rack which is a part of the outer disk of the wheel, while the other pinion engages in a similar rack which forms part of the inner disk. This construction gives the wheel the name "Couple-Gear," since a couple of forces is acting to turn the wheel around the motor, the forces being applied practically at its rim. There is located in the armature shaft an "evener," a device which allows the same amount of power to be transmitted to each pinion. This device is simply a compound knuckle coupling, and is believed to be responsible for the satisfactory operation of the wheel: first, because it removes practically all sliding friction on the gear teeth, thereby increasing greatly the life of the pinions, and, second, because it insures the transmission of equal amounts of power to each side of the wheel, thereby increasing the efficiency and maintaining a true couple.

The efficiency of the gear-drive is remarkable, there being less than 3 per cent loss in the "Couple-Gear" drive. In Appendix A, is submitted a report of the National Bureau of Standards' test on the right front wheel of this car.

Around the casing and bolted securely to it is a channel frame, on which is placed two 36 by 3½ inch solid rubber tires. This construction makes the over-all width of the tire about 8 inches, a width that is very advantageous for travelling over muddy or loose sand roads. The wheel has two circular hand holes for oiling and inspection. The completed wheel is water-tight, as continued immersion has shown. The truck has been called upon a number of times to ford streams in which the wheels were submerged to axle.

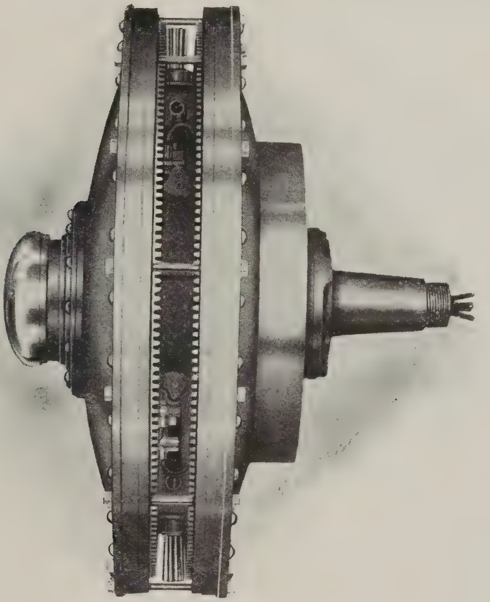


Fig. 3. "Couple-Gear" Wheel with Tire and Band Removed, Showing Relative Positions of Driving Pinions and Circular Rack

FRAME, AXLES, AND SPRINGS

The frame consists of 5-inch channel irons on both sides, connected in the rear by 5-inch channel cross bar and in front by a semi-elliptical formed channel. At a number of points along the frame channel, iron and oak braces are inserted.

The axles are of phosphor-bronze and are of the rigid type, the wheels being held to the axles by knuckles similar to the type used in automobile front axle construction.

The frame is connected to the axles through semi-elliptical

springs arranged to give a three-point suspension. The rear springs are longitudinal, and have at their middle points cushion and recoil coil springs. It has been found in heavy work that it is not the downward, but the upward, movement that breaks a spring. The addition of recoil springs on the car has added greatly to its easy riding qualities; in fact, it is almost as comfortable a riding vehicle as a heavy touring car. The front suspension consists of two semi-elliptical springs placed back to back and securely fastened by a king-bolt. This construction has proven very satisfactory and is very desirable for cross-country travelling.

GENERATING SET

The gasoline-engine generating set consists of a semi-automobile type, 5 cylinder, 4 cycle, 5 by 6 inch Dock, enclosed type gasoline engine specially designed for this service, direct-connected to a 15-kilowatt, Sprague, 6-pole, 85-volt, inter-pole, direct-current, compound generator.

The engine is of a type that may be placed mid-way between those used for gasoline automobile service and those used for stationary service. The automobile type of engine will not satisfactorily stand up to generating service: first, because the parts are not made heavy enough and, second, because the design of cooling water-jackets are not made liberal enough for carrying a continuous load and constant speed. The Dock engine is a compromise between the advantages and disadvantages of a 4 and 6-cylinder type, and for this constant speed work has given excellent service. The engine is fitted with dual system of ignition, consisting of a single coil, battery and high-tension distributor, and an Eiseman low-tension magneto, non-vibrating coil, and the same high-tension distributor. The magneto is used exclusively for running; the battery and coil being used only in cases of emergency and for starting. The engine was originally equipped with an air starting device, but it was later found to be unnecessary, as the cranking method was simple and reliable.

The engine is equipped with a fly-ball throttling governor, McCord force feed lubricator, and Stromberg float-feed carburetor. Gasoline is delivered to the carburetor from a sight reservoir which gets its gasoline from the lower tank through a plunger pump. Gasoline may also be fed from the upper tank direct to the carburetor. The car, as shown in Fig. 2, has a gasoline tank capacity of 87 gallons.

The performance of the generating set is shown by the characteristic curves exhibited in Fig. 5. These curves are self-explanatory.

The generator is of a special light-weight design of the inter-pole type. It is direct-connected to the engine by a flange coupling and is supported on a cast aluminum sub-base integral with the engine base. The inter-pole construction of the generator has made it possible to carry for short periods as high as 75 per cent overload without excessive sparking or heating. This is particularly a good point, since a car of this type will be frequently called upon to pull itself or neighbors out of mud holes or up steep grades.

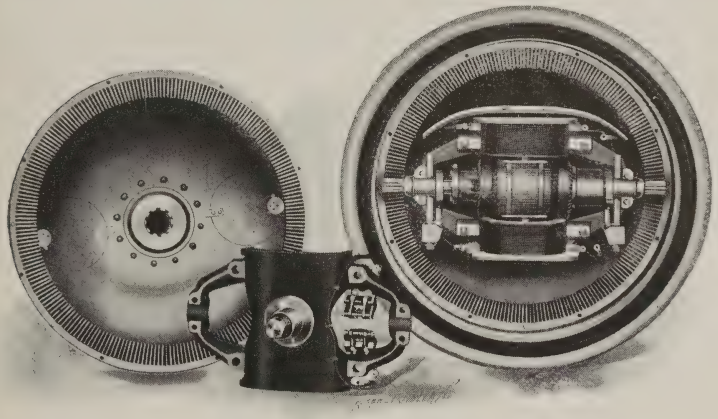


Fig. 4. "Couple-Gear" Wheel with Side of Wheel and Front of Motor Casing Removed, Showing Arrangement of Armature, Poles, and Bearings

The engine is water cooled, the water in turn being cooled in a surface radiator of the Mayo type. This radiator is cooled by air drawn through it from the front of the car by a suction fan which is driven from the generator end of the shaft by a Morse silent chain. It is of such a capacity that the generating set could operate continuously at 25 per cent overload capacity with an air temperature of 100° F. without overheating the jacket water.

CONTROL

The speed of the car is controlled by an eight-point series-parallel, four motor, street car type, drum controller. The current is supplied at constant voltage at from 80 to 110 volts. The first

point on the controller throws two motors in parallel and in series with the other two motors, which are also in parallel; the series parallel combination being in series with the starting resistance. The second and third points reduce the starting resistance and the fourth point cuts out all resistance, but maintains the series-parallel connection. This is the first running point. The fifth point throws all motors in parallel and the combination in series with the starting resistance. The sixth point cuts out a portion of the starting resistance, and the seventh all of it, leaving all four motors in parallel on the full bus-bar voltage. This is the second running point. The eighth and high speed point throws a shunt around the motor fields, thereby giving a greater speed. By this combination any speeds from 3 to 10 miles per hour ahead or reverse can be maintained, a control that can not be obtained efficiently with any other system. This control makes it possible to utilize the available power of the plant in the most economical and desirable manner. It also makes it possible to follow a column of mixed troops or of any one kind of troops.

STEERING AND BRAKES

The car is equipped with four-wheel steer as well as drive. The steering wheel and vertical post are connected to the steering quadrants through a horizontal tumbling rod and worm gearing in such a manner that when the front wheels are deflected to the right the rear wheels are deflected at a corresponding angle to the left. The advantages of this arrangement are that, first, the car can be handled better in tight places and, second, on muddy roads the wheels always track and, therefore, the rear wheels do not have to break a second track when the car travels around curves. The steering mechanism is also equipped with a device, so that by manipulating a small lever on the steering post the rear wheels can be clamped in a straight-ahead position and the two front wheels alone steered. The advantage of this arrangement is that at high speed the car can be more easily and safely operated with the two-wheel steer.

The brakes of the car are both mechanical and electrical. There are external contracting brakes on all four wheels, arranged in pairs; the rear brakes being connected to the right pedal and the front brakes to the left. The electrical braking is accomplished by using the reversing drum of the main controller as an electrical brake controller. In this system the wheel motors are used as gen-

erators, they being connected by the reversing or braking drum to resistances. As soon as the motors, as series generators, are connected by this drum to the resistances they become loaded and tend to stop. The electrical brake is used only in cases of emergency or on descending long grades. The latter use is very desirable, as it saves the foot or mechanical brakes from rapidly wearing away their fiber linings.

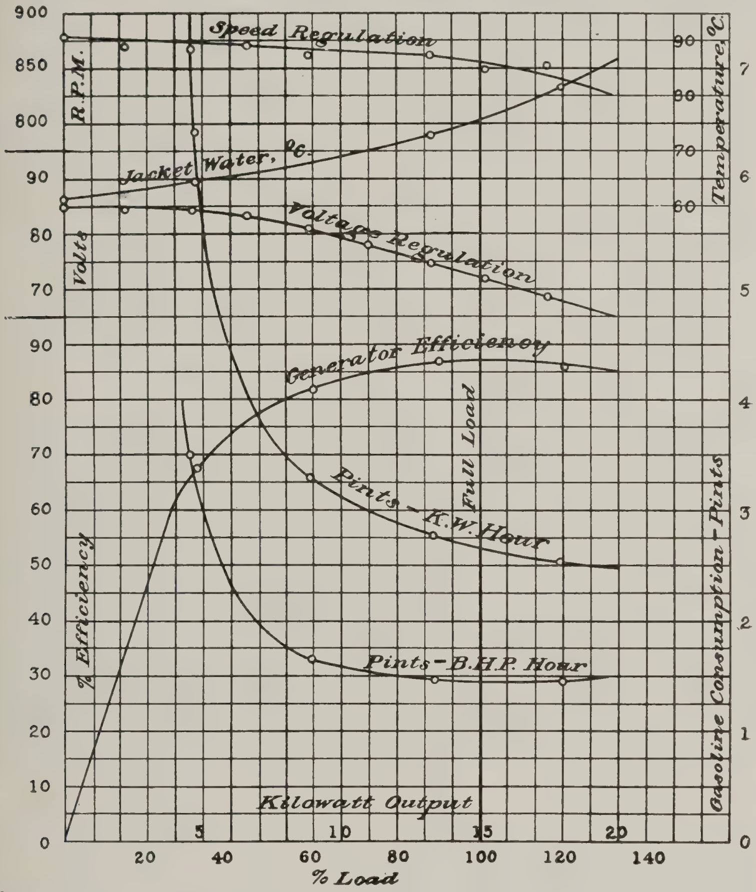


Fig. 5. Test of Dock Gasoline D. C. Generating Set. Five cylinders—5-inch diameter, 6-inch stroke. Sprague Interpolar Generator, 85 volts, 15 kilowatts.

SWITCHBOARD

The dash of the car contains a complete direct-current switchboard for the entire plant. It consists of an automobile volt-

ammeter, generator field rheostat, overload circuit-breaker, and two feeder switches. The circuits are arranged so that the car and two searchlights can be operated independently or together.

The car is equipped with 6-volt electric headlights, tail light, and hand lights. When the plant is not operating, these lights are supplied from the ignition storage battery. This storage battery may be charged from the plant. Ninety-volt hand lights receiving current from the main generator are also provided.

The car is arranged so that a forced draft is created by an exhaust fan at the rear end of the engine hood, which fan is driven by a belt from the main shaft. The air is taken from an inlet above the switchboard at the highest point on the car. This design was necessitated by the fact that the car must operate in a downpour of rain as well as in clear weather. Repeated tests have shown that the car is capable of satisfactory operation in any kind of weather.

The car as originally constructed supplied current to two searchlights. A 24-inch projector equipped with the Le Blanc relay control was mounted on the rear platform, as shown in Fig. 8. With this arrangement the car weighed 10,400 pounds with full tanks having a gasoline capacity of 55 gallons. It was decided to increase the military efficiency of the car and decrease its weight by removing this projector and substituting gasoline tanks to a maximum capacity of 87 gallons. The car as changed is shown in Fig. 2. It weighs, completely equipped with full tanks, 9,800 pounds.

TESTS

Two acceptance tests of ten hours duration each were made in and around Washington. The first test was a run to Baltimore and return. The second test was made over the roughest country roads that could be found in Virginia and Maryland. Streams were forded, soft sandy roads were traversed, operation in ploughed fields was satisfactorily accomplished; the car maintaining this test for ten hours without so much as stopping the engine. The car was equipped as shown in Fig. 8.

The most conclusive test was that made by Lieut. W. F. Endress, Corps of Engineers, and the writer (Wheeler) from August 11 to 15, 1909, on a road trial from Washington Barracks, D. C., to Harrisburg, Pa., via Baltimore, Md., and York, Pa., and return via Gettysburg, Pa., and Hagerstown, Md., over the Blue Ridge Mountains. The automobile roads in many places were not trav-

elled, as the most difficult country roads were sought for. A summary of this test is given in Appendix B. As will be noted, the generating plant was started at Hagerstown on the last day of the trip and ran continuously until shut down at Washington Barracks, a total of twelve hours and nine minutes.

The car on this test was equipped as shown in Fig. 8. Total weight, including the two operators, was 10,850 pounds, with full tanks.

Attention is called to the fact that on this trip the car made 1.45 miles per gallon of gasoline. Shortly after this test was made a Stromberg carburetor was substituted for the Shebler used during this test. Comparative tests over a 20 mile run of the same road on the same day under exactly the same conditions showed that the car equipped with Shebler carburetor gave 1.55 miles per gallon of gasoline, while when equipped with the Stromberg it gave 2.33 miles per gallon of gasoline; a gain of 50 per cent in mileage on a given amount of gasoline.

Fig. 6. Auto-searchlight Climbing 25 Per Cent Grade

Fig. 6 shows the car climbing a 25 per cent grade at Grand Rapids the first day it was operated. Fig. 7 shows the car turning around on the same grade. This illustration is reproduced to give an idea as to where the center of gravity is located.

Tests for draw bar pull were made at Washington Barracks with a Fairbanks spring dynamometer. The car, equipped as shown in Fig. 8 and weighing approximately 5 tons, gave a standing draw bar pull of 5,000 pounds with the controller on the series-parallel points. At this pull the wheels began to slip. This pull was obtained by bringing the car taut against the spring dynamometer and gradually increasing the voltage applied to the motors.

Another test for grade climbing is shown in Fig. 8, in which the car is shown starting to climb the steps at the west end of the approach to the Army War College at Washington Barracks.

A test for operation over rough ground is shown in Fig. 9. The car is here shown operating over one-half yard dump-cart loads of loose earth that had been dumped close together on the parade ground at Washington Barracks. Some of these piles of dirt were approximately the height of the wheels, 36 inches, but still the car had no difficulty whatever in running over them. Attention is also called to the advisability of using a three-point suspended frame for a car that is to operate over rough ground.

CONCLUSIONS

From a careful study of the design and performances of this outfit it is believed that the following conclusions are justified:

For such conditions as would be encountered in field operations by the United States Army, the heavy truck type of self-propelled generating plant will be more satisfactory than the automobile touring car type.

For the heavy truck type the four independent motor-driven wheel drive on the "Couple-Gear" principle will be more satisfactory than the usual form of automobile mechanical drive through clutch, gear, and differential.

In view of the recognized desirability of replacing animal traction for supply trains, ponton trains, etc., by mechanical traction, experiments with such a truck as a tractor are justified; especially since commercial trucks constructed on the same principles are now on the market, and are being used with very satisfactory results for this same class of work. A reference to the tentative organization of the British searchlight company, previously described, will show the saving in men and animals that can be effected by mechanical traction. Five men are sufficient for the operation of the auto searchlight car with its trailer.

With the engineer train an outfit of this type will be especially

valuable as, in addition to its uses as a generating plant for searchlights and as a tractor, it can furnish power for pile drivers, derricks, pumps, concrete mixers, etc., and incandescent lamps in camps, galleries, and mines. A portable field pile driver with motor-driven hoist has been designed and built for use with the auto searchlight car.

It is admitted that both the car and trailer of this experimental set are very heavy, but the writers are convinced that by redesigning the entire equipment a saving of from 2,000 to 4,000 pounds in weight can be effected.

Fig. 7. Auto-searchlight Turning on 25 Per Cent Grade

FIELD ARTILLERY SET

The experimental Field Artillery set is shown in Fig. 10. It comprises two units—the generator unit and the searchlight unit—each of which weighs 4,700 pounds complete. The generator unit carries a gasoline-engine generating plant, composed of a General Electric 4 cylinder, 4 by 5 inch gasoline engine running at 700

r. p. m. direct connected to an 80-volt direct-current generator of 7 kilowatts capacity. The pistons, crank pins, crank and cam shaft bearings and all concealed working parts are oiled by splash lubrication. The engine is fitted with a General Electric carburetor and a Bosch low-tension magneto with magnetic spark plugs. The radiator is mounted in the rear of the truck and the muffler on top, as shown in the figure. A compact switchboard, gasoline tank of 30 gallons capacity, and tool and supply box also form part of the generating unit. Heavy canvas side curtains and a sheet-iron canopy top enclose the working parts; the side curtains may be rolled up when desired. Standard artillery wheels are used for both units.

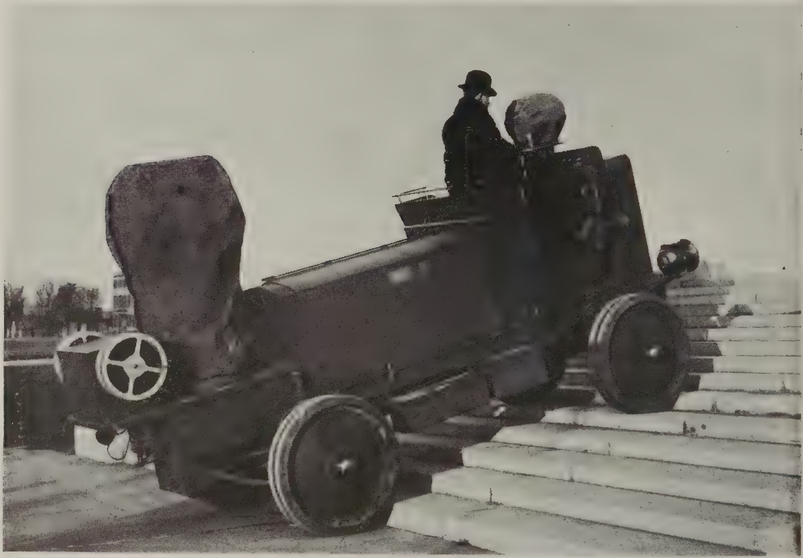


Fig. 8. Auto-searchlight on Steps of Army War College

The searchlight unit comprises a General Electric 30-inch projector of latest type with gold-plated metal mirror and new General Electric controller. Five hundred feet of supply cable are carried on the rear reel and the same amount of controller cable on the front reel. Travelling trunnions are provided for greater security of the projector drum. The drum can be left in the operating trunnions for travelling short distances or for longer distances

when the ground is not too rough. The controller, tools, carbons, spare parts, etc., are carried in the tool box under the seat.

PORTABLE TOWER

The recognized advantages in securing a certain amount of command for the projector has led to the development of the portable telescoping tower shown in Figs. 11, 12, and 13. This interesting contrivance is of German invention and remarkably ingenious in construction. It is equipped with an old 24-inch General Electric searchlight with glass mirror, which has been arranged for distant control by either a Le Blanc controller or one of the old 6-wire type described in Artillery Notes No. 31.

Fig. 9. Auto-searchlight Travelling Over Cartloads of Loose Earth

Fig. 11 shows the tower and projector in the travelling position. For raising, the tower is first turned over in the trunnions to the position shown in Fig. 12. The projector is then slid along in a special track to its support in the elevating frame and clamped in position, as shown in Fig. 12. The rear posts of the base section of the tower are provided with foot plates and levelling screws, so that the tower can be erected in a vertical position on uneven ground. The upper half of the tower telescopes inside the lower, and is raised from the position shown in Fig. 12 to that in Fig. 13

by means of a hand-operated crank windlass attached to the lower part of the base section. For lowering, the windlass is provided with a friction brake. The elevating frame on which the searchlight rests slides inside the upper section of the tower and, by an ingenious arrangement of pulleys, is caused to rise from the bottom to the top of the upper section while the upper section is rising inside the lower. The final position is shown in Fig. 13. The tower is well braced and is remarkably rigid. Guys may be attached to the four corner posts if desired. Five hundred feet of supply cable are carried on the reel underneath the body, and 1,000 feet of control cable on the two reels on either end of the chest under the seat.

The auto-searchlight truck with its trailer, the Field Artillery set, and the tower were all operated by officers and enlisted men of the First Battalion of Engineers at the maneuvers at Gettysburg and Pine Camp during the last summer, and it is expected that the results of the work will be described by the officers in charge in other papers in the MEMOIRS.

APPENDIX A

DEPARTMENT OF COMMERCE AND LABOR,
BUREAU OF STANDARDS,
WASHINGTON, D. C., *June 9, 1909.*

Certificate for Couple-Gear Automobile Truck Wheel

Maker: Couple-Gear Freight-Wheel Company. Submitted by Mr. M. B. Church, President, Couple-Gear Freight-Wheel Company, Buchanan Street, Grand Rapids, Mich.

The wheel was driven by an electric motor enclosed entirely within it, so that the wheel with its enclosed rigidly attached gear racks formed the driven member, while the driving member was made up of the motor within the wheel, having a beveled pinion at each end of its armature, engaging the racks at the outer edge of the wheel, and carried by the armature shaft which had within it an equalizing device or ''Evener,'' the power being transmitted through this balanced driving unit at a reduction of approximately 25 to 1, direct from the high speed armature to the point of delivery.

The over-all efficiency of the motor and wheel together was determined by a Prony brake test. The wheel was then removed and the efficiency of the motor alone determined by a second Prony brake, but with all other conditions as nearly alike as

Fig. 10. Field Artillery Searchlight Set

possible. Records were kept of the current and voltage supplied to the motor field and only those readings were used in the calculations which showed that the field winding had the same resistance, and hence the same temperature in the two tests. The applied voltage was held at 100 in all cases.

The accuracy of the measurements was limited by the nature of the test to about one per cent.

Current in amperes.		Efficiency of motor and wheel.
25	75 per cent of normal load	76 per cent
33	Normal load	76 per cent
50	50 per cent overload	72 per cent

The average value found for the power absorbed in the transmission gears and roller bearings of the wheel for the three different loads above specified was two and one-half per cent of the total power delivered to the wheel by the motor. That is, the average efficiency of the transmission gear was 97.5 per cent.

E. B. Rosa,
Acting Director.

DISCUSSION

Lieut. RICHARD PARK
Corps of Engineers

The writer was in immediate charge of the care and operation of the United States Army field searchlight outfit operated at the maneuvers at Gettysburg and Pine Camp during the last summer. In connection with the article on "Field Searchlights" by Lieut. W. H. Rose, Corps of Engineers, and Mr. Earl Wheeler, it may be interesting to discuss some of the points brought out in that article in view of the experience gained during the practical test of the outfit.

The auto-searchlight truck with its trailer searchlight, the tower light, the Field Artillery generator, and the Field Artillery light, were all taken into the field, and, besides being operated a considerable number of times in camp, to keep the apparatus in good order and to train the details, there were the main tests in five night attack problems: two at Gettysburg, in one of which the lights were on the defense, in the other on the offense; and three at Pine Camp, in two of which the lights were located on the defense, in the other on the offense.

The purpose of the experiment was two-fold: to determine the

ROUTE		Total Miles Run	Total time between points	Actual running time of car	Actual running time of motor	Average speed between points	Average running speed	Total time lost in stops	Total gasoline consumption	Miles per gallon of gasoline	Total cylinder oil consumption	Cyl. oil consumption per hr. run. time of motor	Miles per gallon of cyl. oil	Average Voltage	Max. Amperes	Max. Grade	REMARKS
From	To		HOURS MINS.	HOURS MINS.	HOURS MINS.	M.P.H.	M.P.H.	%	Gals.	Gasoline	Gals.	Gals.	Miles	Volts.	Amps.	%	
Wash. Bks. D.C.	Bel Air, Md.	63	12° 41'	9° 19'	9° 19'	4.97	6.75	26.37	45.80	1.38	1.16	0.125	56.5	85	160	14.0	Good hilly State Road to Baltimore. Very poor State Road to Bel Air, Md. Stopped Engine at Winans' because of explosions in moefler due to water in distributor.
Bel Air, Md.	York, Pa.	45	9° 36'	7° 34'	7° 34'	4.69	5.95	21.1	30.63	1.47	0.75	0.099	60.0	85	185	18.0	Good dusty and sandy country roads. Stopped to refill lower gasoline tank. No engine troubles.
York, Pa.	Harrisburg, Pa.	30	5° 20'	4° 47'	5° 7'	5.63	6.27	10.2	23.33	1.29	0.396	0.079	75.8	82	200	24.0	Very hilly, rocky and dusty country roads all the way. Governor pin slipped out allowing engine to race. Repaired on road. Engine flooded at start.
Harrisburg, Pa.	Gettysburg, Pa.	37	7° 47'	6° 52'	7° 2'	4.76	5.39	11.7	27.60	1.34	0.771	0.108	48.0	85	160	14.0	Good rolling State Road to Mechanicsburg. Good dusty country roads to Gettysburg. Stopped to equalize gasoline in tanks. 45 minutes lost.
Gettysburg, Pa.	Hagerstown, Md.	34.5	5° 40'	5° 24'	5° 40'	6.10	6.40	4.5	21.10	1.64	0.594	0.105	58.1	80	270	26.0	Very hilly macadam compony pike across mountains. Rear wheels made noise due to excessive heating by band brakes. Engine ran perfectly.
Hagerstown, Md.	Wash. Bks. D.C.	86	12° 9'	11° 3'	12° 9'	7.08	7.78	9.0	55.35	1.56	1.506	0.124	57.1	88 110	160 150	9.0 6.5	Good National Pikes with the exception of 12 miles from Cookville to Brookville which was good country roads. Engine ran perfectly. Main bearings getting noisy
Wash. Bks., D.C.	Wash. Bks. D.C.	295.5	53° 13'	44° 59'	46° 51'	5.55	6.58	15.5	203.8	1.45	5.18	0.1105	57.05	84	270	26.0	In general, average dusty roads. Majority State Roads or compony pikes. Dirt roads better than pikes for the car. No adjustments made on car or engine. Air connections gave some trouble.

Electrical and Mechanical Engineering Department, Engineer School

August 11-15, 1909

Results of Road Test of Experimental Auto-searchlight

fitness of the various types of apparatus, and also to ascertain the possibilities and limitations of searchlight work with a field army.

The auto-searchlight truck, hauling its trailer, was run over the country roads to Gettysburg in rear of the troops marching from Washington to the maneuver camp. At Gaithersburg, Md., a 25 per cent grade was encountered, and it was found that in order to haul the trailer up it was necessary to carry for five or six minutes as much as 200 per cent overload on the wheel motors; this was on a good bottom and with the entire plant in good condition. Any good series motor should stand this overload momentarily and if not too often applied, but it should not be expected to stand it for a prolonged period.

Under "Tests," Mr. Wheeler says: "The second test was made over the roughest country roads that could be found in Virginia or Maryland." This is very probable, for the truck acting alone will not be stopped on any road grade of whatever degree of roughness, provided it has a hard surface on which the wheels can work. These roads could not, however, have been very sandy or very deep with mud, for time and again the truck showed its helplessness when mud, wet clay, or soft sand on grades, was encountered, and this without the trailer. As a matter of fact, it would be impossible for such a heavy car to be fitted with motors powerful enough to move it through some of the mudholes which are encountered on the roughest country roads, for, on account of its great weight, it would sink in faster than it could move forward.

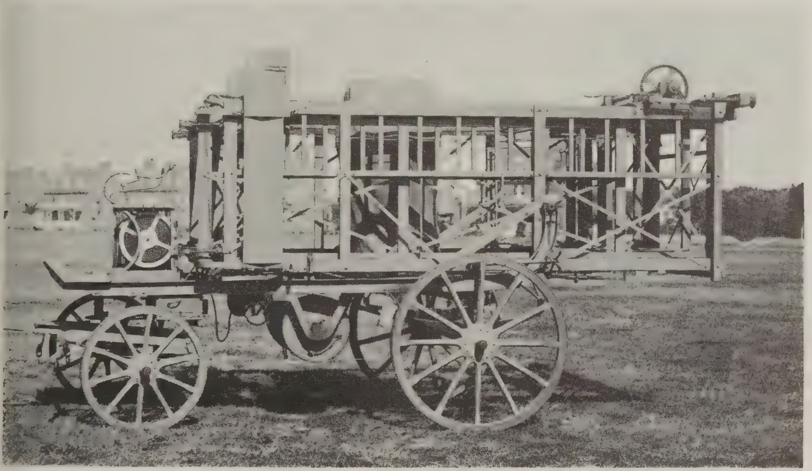


Fig. 11. Searchlight Tower in Travelling Position

In deep sand the machine is stopped. This was demonstrated at Pine Camp, when grades of from 15 to 25 per cent, covered

with a foot of soft damp sand, were attempted. The machine alone could not begin to negotiate the climb because the wheels would sink down until the up-pressure on them was the same as the weight of the machine, which depth would vary from 6 to 12 inches. Then the effect is that of a greatly increased grade, on account of the sand compacted in front of the wheels interposing a solid wall to be climbed.

In regard to the above account, it may be said that the truck was actually driven through the deep mud and up sand hills with the grades mentioned, but not of itself alone. Fence rails were procured in one instance and laid in the mud. The instant the powerful wheels could get a grip on the rails the truck ploughed through mud in which the wheels seemed to find no bottom otherwise. The same thing was true in the sand. The truck was forced over 25 per cent grades through deep sand on an improvised track of fence rails and boards, when it could not be made to budge in the loose sand ruts.

In regard to the test of operations in ploughed fields, I do not think it can be said that such a test was satisfactorily accomplished. It is true that at the maneuvers the truck, hauling its trailer, was repeatedly run into oat stubble fields to searchlight positions. It had all it could do to traverse this fairly solid turf, the wheel motors in series-parallel carrying a 200 per cent overload much of the time on grades of from 5 to 10 per cent in the fields. After this experience the truck was never tried through freshly ploughed ground, but at Pine Camp all ground encountered was soft, when off the roads, and the roads themselves heavy with sand and loam. The trailer was hauled from the Quartermaster Depot to the Engineer camp, with the motors in series-parallel carrying full load on the level, and when even a slight grade was encountered the overload increased out of proportion. Since it was out of the question to haul the trailer up any considerable grade, and since on any of the roads no speed faster than in series-parallel (1 mile per hour in the soft ground) could be maintained, it was not attempted to haul the trailer at Pine Camp but once, this office being performed by mules which hauled a chess wagon with the trailer attached behind.

This goes to prove that although the truck can not negotiate of itself deep mud with soft bottom or deep sand on grades, swampy, or ploughed land, still with the proper appliances, such as a temporary track composed of a few angle irons or channel irons, it can forge its way over most any ground.

I agree with the writers' conclusion that in the United States the heavy truck type is preferable to the automobile touring type, and that the ''Couple-Gear'' principle is superior to the mechanical drive principle of the touring car type.

With reference to this first experimental design it will be noticed that the truck carries a 15-kilowatt generator with an engine rated at 50 horsepower, and is designed to carry a double searchlight

load, each taking 7½ kilowatts, approximately. Now, the wheel motors at full load take only 9 kilowatts. If it were necessary to design a 15-kilowatt set to carry a double searchlight load then the wheels should have been designed so as to consume 15 kilowatts instead of 9. As the truck stands it is, so to speak, weak on its legs.

The writers admit that this experimental machine is too heavy and they think it can be lightened. It can without doubt be much lightened, but to utilize its whole power most efficiently and economically, it should be equipped with larger wheels of the same type having motors of 4 horsepower capacity each. If this is done the truck will haul its trailer and five men up any grade to 35 per cent, and through 2 feet of mud if a hard bottom is reached, while its tractive power in loose deep sand will be much increased, although the tests over the Pine Camp sand drifts showed that there is a limit to such traffic unless some side means such as rails, to give a firm bearing surface, are used.

Fig. 12. Searchlight Tower in Intermediate Position

As the machine stands, we have the incongruity of a light 9-kilowatt set of wheel motors propelling a heavy 15-kilowatt generator run by a 50-horsepower engine, with the additional heavy equipment in proportion. The task of the wheel motors now installed in this truck, considering the efficiency of the wheel motors

as 75 per cent, should be to propel a 12-kilowatt generator run by a 40-horsepower engine with its corresponding lighter equipment. In this case it could undoubtedly haul its trailer.

The base of the engine is an aluminum casting. During the summer's test it cracked in a number of places. It should be made of the best cast steel, or manganese or phosphor bronze.

The intake valves should be of the same type as the exhaust valves and installed in the same way.

The radiator is one of those things which we referred to above as being a heavy appendage of a 15-kilowatt, 50-horsepower set, to be carried as an extra load by a 9-kilowatt set of wheel motors.

The truck looks top-heavy, but is not. The operator's seat is high but light, and the steel-hinged covers of the engine are light, with the engine placed low enough inside. If larger wheels are designed, however, the distance of the center of gravity of the engine above ground should remain the same or even be placed a trifle lower.

The writer (Wheeler) states that a car of this type will be frequently used to pull itself and neighbors out of deep mudholes, and that the generator can carry 75 per cent overload for short periods. This does not very well work out in practice, since the generator is only called on for a 14 per cent overload in order to overload the wheel motors 100 per cent in parallel or 300 per cent if in series-parallel, which latter would always be used for extra heavy pulling.

The electric brake is a feature which should be used with the utmost caution. When the car is at speed, the effect of its sudden application on the motor armatures may be very damaging, since it is to short-circuit the armatures of the wheel motors now acting as generators.

The trailer principle is not correctly applied. The drag on the tractor could be much lessened if it were made to carry part of the weight of the trailer. All the power cable of the trailer might be carried on a reel on the truck, and the trailer light should be carried on carrying trunnions so placed that one-half the weight would be carried by the truck and one-half by the trailer axle. The heavy castings of the light itself should be made of aluminum.

In regard to the Field Artillery set, it may be explained that it is drawn by mule power, each unit being light enough to be hauled over ordinary roads by four mules and almost anywhere with six.

After two months operation in the field with this set it can be said that no essential defects were found in it, except that the yellowish beam reflected from the gold-plated projector did not seem to be as good as the white beam from the white metal mirror of the trailer light. The white beam appeared better for land operations, but this may have been due to the condition of the reflecting surface of the gold-plated projector, which was not very well polished.

In addition to its present equipment a diverging lens should be

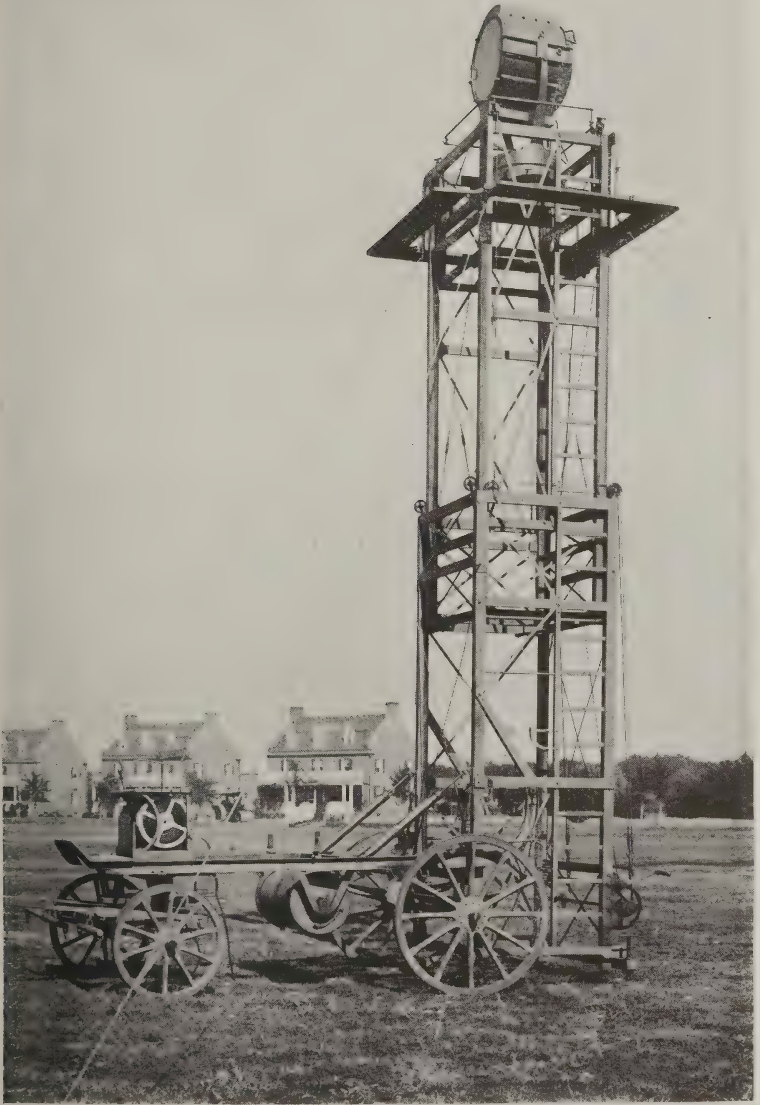


Fig. 13. Searchlight Tower in Operating Position

supplied, in order to enlarge the field of view for near-at-hand illumination and still retain all the light.

The electric control when finally understood was perfect electrically, but is of the type supplied to the seacoast lights and not rapid or elastic enough for inland work.

Both units are strongly and simply made, and on the road and when in operation, are first-class machines. At the present stage it would seem that mule or horse drawn units are more suited to American roads than automobile units.

The tower truck equipped with the old 24-inch General Electric searchlight was used at all of the night maneuvers, and although handled indifferently well at Gettysburg, was used very effectively at Pine Camp. The elevation of the light, some 30 feet above the ground, gives great advantage over a light on the ground. No better apparatus could be desired than the collapsible tower itself. The truck, however, is not adapted to our roads. The rear wheels are spread, so as to make room for the tower frame, to a wider gauge than the front wheels. Whatever the gauge, the front and rear wheels should track. An endeavor should be made to design the truck with standard gauge tread. Trouble was also found with the narrow-tired wheels of the tower truck. For American roads wheels should have at least 4-inch tires.

The General Electric light installed in this tower truck did excellent service at Pine Camp, but, of course, a standard light should be installed. The present tower will support a 30-inch light. At Pine Camp on one occasion there were six men on the raised tower, three of these being sharpshooters who were up there for the purpose of picking off the enemy's officers, mounted men, and individual skirmishers.

The above remarks are intended merely as suggestions on points brought out in Lieutenant Rose and Mr. Wheeler's article. It is hoped, in a later issue of the MEMOIRS, to discuss the operations of the outfit at the two maneuver camps, and go more into the details of practical searchlight work with a mobile army in the field.

Capt. L. H. RAND

Corps of Engineers

From my report upon operations of the Engineer Battalion, Pine Camp Maneuvers, during the summer of 1910, I quote as follows:

"It was noticed the searchlights were very helpful in open country and virtually helpless in closed country in picking up an advancing enemy. In open country the light can be moved slowly enough to permit reasonable observation in its field without affording the enemy opportunity to gain concealment. In closed country, unless the light is switched from point to point rapidly those on whom the rays are intended to be turned can see them approaching, with time to take cover; while if the movement is rapid the shadows of the brush and trees present fantastic appearances that readily

lead the imagination to deceive the sense and it is only by luck that there may be an objective in the field of view at the moment of pause. Even in closed country, however, it is believed the lights have the advantage for the defense of permitting its nearby outposts, and patrols along its front, to more effectually keep in touch with what is going on in their immediate vicinity, and the blinding, confusing effect of the light when played on an approaching enemy renders him momentarily helpless and very vulnerable. The general illumination that it is possible to give the general front, in addition to distinct searching qualities if a pronounced salient can be safely found for the light, is also very helpful to the troops whose foreground is thus covered. Care must be taken in such a case, however, not to turn the light on any part of its own lines (as was done in one instance) for then it is found that for several minutes the troops there are helpless until their eyes recover normal condition. With the confusion of direction that results from their use the searchlights seem to prove a magnet for an approaching foe, as they all seem to move toward the light. Probably the realization that the light is with their enemy and inability to fix on anything else gives rise to this.

"To gain the full advantage of the light it would seem that the front should be well covered with such an open artificial obstacle as an entanglement, in which case particularly is it desirable to have the light well above the plane of site, either on a natural rise or an elevated tower. The light also seemed to have a demoralizing effect on animals unused to it on the few occasions when they came into its rays. Any of the present distant controls are too slow in operation for the sudden movements that are necessary.

"It did not appear that any of the larger electrically operated lights would be advantageously used by an attacking party. The small calcium light type, portable by individual soldiers, could be effectively so used, as its range is suitable for the very close work that the element of surprise that should exist in night attacks makes necessary; its operation is quiet and does not reveal its proximity or location by its noise, and it can be instantaneously started to its full illuminating effect."

It would seem that for field, as distinct from siege, operations, the more readily portable calcium lights give better promise than the electric lights. The latter, however, are alone sufficiently powerful for siege operations and field expeditions approaching them in characteristics. The general type of electrical light, as described, showed its adaptability to service conditions, and with minor improvements—in detail well known to those immediately in charge of operations with the lights—would seem to answer every need. It is believed, however, that a lighter tripod type of tower, with easily fitted and removable connections, could be designed to take the place of the German type of tower used. It is also believed that the system of developing the heat for the calcium light might better be analogous to that of some American system, to utilize the more readily available commercial materials.

NEW RIVER AND HARBOR IMPROVEMENT PROJECTS

BY

Capt. E. N. JOHNSTON
Corps of Engineers

It is believed that the present interest in matters relating to the improvement of the waterways of the country is such that some interest may be taken in the following notes, prepared mainly from official reports of officers of the Corps of Engineers.

The River and Harbor Act which was signed by President Taft on June 25, 1910, contained appropriations aggregating $41,329,113.50 and authorized an additional sum of $10,618,605 to be pledged on contracts. Of the funds appropriated or authorized, $25,593,160 will be used in prosecuting 140 projects which had been previously commenced, $2,454,110 will be expended for maintenance of 138 works already completed, while the balance of $23,900,448.50 will be expended in work upon 175 new projects. In addition to the 453 new and old projects for which provision is made in this act, there are many other works now under way for which the funds previously provided are sufficient to cover the work which can be done during the next year.

One feature which distinguishes this act from others which have preceded it, is the adoption of a policy which indicates the intention of Congress to provide funds at rates sufficient to insure the completion of the most important projects within a definite and reasonable number of years. For example, the act adopts a new project for the Ohio River "with a view to the completion of such improvement within twelve years;" for the Upper Mississippi River "with a view of completing said improvement within a period of twelve years;" for the Mississippi River, below the mouth of the Missouri, and above the mouth of the Ohio "with a view to completion within twelve years;" for the Mississippi River below the Ohio River "with a view to completion within twenty years;" for a deeper channel to Mobile "with a view to completion within four years," etc. Such a provision is of service to the engineers charged with the execution of the work, since it authorizes such a disposition of the funds appropriated as will

lead to the maximum economy, assuming that Congress has practically pledged itself to provide funds at the rates necessary to insure completion of the projects within the periods stated. In the past, the funds have not generally been provided at rates necessary for economical prosecution of the works.

The interest of the Federal Government in the improvement of waterways arises from "the commerce clause" of the Constitution, and until recently no ground was advanced for improvement by the Federal Government except the necessities of commerce. All plans of improvement have been thus limited. The act of March 3, 1909, however, prescribed:

> "That every report submitted to Congress in pursuance of this section, in addition to full information regarding the present and prospective commercial importance of the project covered by the report, and the benefit to commerce likely to result from any proposed plan of improvement, shall contain also such data as it may be practicable to secure regarding (first) the establishment of terminal and transfer facilities, (second) the development and utilization of water power for industrial and commercial purposes, and (third) such other subjects as may be properly connected with such project: *Provided further,* That in the investigation and study of these questions consideration shall be given only to their bearing upon the improvement of navigation and to the possibility and desirability of their being co-ordinated in a logical and proper manner with improvements for navigation to lessen the cost of such improvements and to compensate the Government for expenditures made in the interest of navigation."

In compliance with this law, the related subjects mentioned in the act are now given very careful consideration in connection with all proposed improvements. For example, in the case of canalization schemes consideration is given to the possibility of an ultimate saving by the construction of high dams and the development and sale of water power, etc.

An instance of this is found in the revised project adopted by the 1910 act, for the Mississippi River between Minneapolis and St. Paul. That portion of the river has been under improvement under a project, adopted many years ago, involving two locks and dams with lifts of 13 feet each, to provide a 6-foot navigable depth. Under the authority granted by the act of 1909, a careful study was made of the possibility of reducing the ultimate cost to the United States, and at the same time conserving the water power. This resulted in a recommendation to Congress that the lift of the lower dam be increased to 30 feet, thus making possible a water-

power development of about 15,000 horsepower. The original project was ample in all respects for present or reasonably prospective navigation, and to complete the canalization by means of the high dam will cost $230,000 more than by completing the lower dam with a lift of 13 feet.

However, the newly adopted project will provide a depth of at least 9 feet, instead of 6 feet, from the site of the lower dam (near Minnehaha Falls) to Minneapolis, thus affording increased facilities for navigation. The additional cost of the project will be recovered in a short time from the sale of the power which will be created by the high dam. The water power will be conserved and there will be a perpetual surplus revenue for the Government. In this connection, it might be remarked that the interest of the Federal Government in the waterways of the country extends only to their control in the interest of navigation. The Federal Government has no possessory interest in the water power created by dams constructed by interests other than the Federal Government itself. Under our present form of Government the control of the water power pertains to the individual States; however, when the power is created as a result of expenditures made by the United States the case is different; the Government owns the power thus created and can use it or dispose of it the same way as any individual owner.

NEW YORK HARBOR

One of the costly projects adopted by the present act is that which initiates the work of construction of a deep-water harbor in Jamaica Bay, Long Island, the entrance being through Rockaway Inlet. The work is to be undertaken by the United States in coöperation with the city of New York. It has been stated that in ten years the available sites for wharfage around Manhattan and upper New York Bay will be exhausted. The new harbor will provide for a very great extension of wharfage. The project adopted provides for the excavation of an entrance channel 18 feet deep and 500 feet wide through Rockaway Inlet, its enlargement when needed to 30 feet deep and 1,500 feet wide, and the excavation of a main channel in the bay 30 feet deep by 1,000 feet wide and over 8 miles long, aggregating 70,000,000 cubic yards of excavation. This amount is not far from the amount of excavation necessary in the famous Culebra Cut of the Panama Canal from the date upon which work was commenced by the United States. The project also includes an east and a west jetty, 7,000

feet and 10,000 feet in length, respectively, to be constructed if experience indicates their necessity. In addition to the above work, which will be done by the United States at a total cost of $7,430,000, the city of New York is to build piers and bulkheads along the main channel, the estimate of cost of the work to be done eventually by the city aggregating about $69,000,000, including the cost of land reclamation, concrete bulkheads, 112 piers of the Chelsea type, etc.

THE HUDSON RIVER.

The portion of the Hudson River which has been under improvement by the United States Government is that portion about 28 miles long between Coxsackie and the State dam above Troy. Before improvement there was a channel 6½ feet deep up to Albany, 6 feet deep to Troy, and about 5 feet to the State dam. This dam is provided with a small lock, 28 by 130 feet, with a depth of 4½ feet on the lower miter sill. As a result of the work of improvement there is now a channel 12 feet deep at mean low water with a least width of 190 feet from Coxsackie to Troy, and a depth of 11 feet with a least width of 75 feet to within a short distance of the State dam. This improvement upon original conditions has been effected by dredging, rock removal, the construction of training dikes, etc. The State dam is too low to provide a sufficient depth over the lower miter sill of the lowest lock of the State Barge Canal, the terminus of which is at Waterford, about 2½ miles above the dam. Immediately below the dam is a rock ledge with only about 4½ feet of water over it. The full value of the work now under way by the State of New York cannot be realized unless this portion of the Hudson River is still further improved. The act under way by the State of New York can not be realized unless this portion of the Hudson River is still further improved. The act of 1910 adopts a new project which includes the construction by the Federal Government of a new lock and dam to cost about $540,000; the removal of the old State lock and dam; about 7,000,000 cubic yards of dredging; about 400,000 cubic yards of rock removal, and the construction of dikes and training walls. The improvements above outlined are designed to afford a channel at least 12 feet deep at all stages of the river up to Waterford, the channel to be 400 feet wide below Troy (with harbor basins at

Albany and Troy) and 200 feet wide from above the new dam to Waterford. The entire work is estimated to cost $5,186,064.

NORFOLK HARBOR.

Norfolk Harbor has been under improvement since about 1876, when the available depth was about 20 feet and when the value of the exports was about $6,000,000 per annum. The latest work done has been under a project adopted by Congress in 1907, which provided for a channel 30 feet deep, which will be completed in 1911. The value of exports has greatly increased in thirty years, being now about $600,000,000, showing the advantage commerce has taken of the increased facilities. The total cost of all work ever done by the Government at Norfolk (including the amount required to complete the 30-foot project) is about $3,000,000, which is about one-half of 1 per cent of the value of the commerce for a single year. The act of 1910 adopts a project for a channel 35 feet deep and 400 feet wide from the ocean to the Navy Yard at Norfolk, and 25 feet deep and 300 feet wide for some distance in the southern branch of the Elizabeth River above the Navy Yard. This new 35-foot project will involve the excavation of about 10,000,000 cubic yards and will cost about $1,712,500. It will give Norfolk an entrance channel of the same depth as has recently been provided for Baltimore and as will soon be completed for Boston. The 40-foot Ambrose Channel to New York is already completed to a depth of 40 feet for a width of more than 1,000 feet; its width when entirely completed will be 2,000 feet.

THE DELAWARE RIVER

For the Delaware River the act of 1910 adopts two new projects. The work already done between Trenton and Philadelphia has been confined to the removal of shoals to provide a channel with a depth of 7 feet over a width of 200 feet. Under the new project a depth of 12 feet will be obtained at a cost of about $360,000. The work will include about 1,100,000 cubic yards of dredging and the construction of dikes to concentrate the currents.

Up to June 30, 1909, the Government had dredged about 58,000,000 cubic yards from the portion of the Delaware River at and below Philadelphia, thus obtaining a channel 30 feet deep by 600 feet wide. Philadelphia has a valuable and rapidly increasing commerce which can not be successfully handled in the present depth of 30 feet, many vessels being compelled to load to less than

their full capacity. The foreign commerce of Philadelphia for 1909 was valued at $158,000,000. The new project is for a channel 35 feet deep and 800 feet wide with increased width at the bends from Philadelphia to the sea. This will involve the excavation of about 73,000,000 cubic yards of soft material and 53,000 cubic yards of rock, an amount of excavation approximately equal to that of the Culebra Cut of the Panama Canal. Dikes will be built to control the tidal flow and thus assist in maintaining the channel. Of the 63 miles between Philadelphia and the 35-foot depth in Delaware Bay, dredging will have to be done throughout all but 5 miles. The new project is estimated to cost about $11,000,000 and will probably require about six years to complete, if funds are appropriated in sufficient amounts at the proper time.

CHARLESTON HARBOR

Previous to the improvement by the Government of the entrance to the harbor of Charleston, S. C., the greatest depth over the bar was 12 feet. By the construction of a north jetty and a south jetty, 3 miles and 4 miles long, respectively, and by auxiliary dredging a channel with a depth of 26 feet and width of 600 feet has been obtained. This channel, after it leaves the outer ends of the jetties, is not in exact prolongation of the jetty channel, because of the formation of a shoal formed by material scoured from between the jetties. The new project provides for the formation by dredging of an entrance channel 28 feet deep, 500 feet wide between the jetties and 1,000 feet wide beyond them, thus straightening out the outer portion of the channel over the bar. The work involves about 3,400,000 cubic yards of dredging estimated to cost about $371,000. Besides the advantages to commerce, this increased depth will be of advantage in connection with the Charleston Navy Yard.

ST. JOHNS RIVER

In 1879, there was a depth on the bar at the mouth of the St. Johns River, Florida, of only 6 feet at mean low water. In 1880, work was begun on a project which included the construction of two long jetties converging from the opposite shores at the mouth of the river until near the bar and then extending parallel to each other and 1,600 feet apart across the bar. The jetties have been built to lengths of 13,000 and 11,000 feet, various training walls and cut-off dams have been built in the river proper below Jack-

sonville, and certain dredging in the river has been done. As a result, there is a stable channel at least 24 feet deep from Jacksonville 27 miles to the ocean. This depth was obtained across the bar by scour unaided by dredging, the increase of depth across the bar being about 18 feet. The commerce of Jacksonville has increased from 196,000 tons in 1879 to 2,500,000 tons in 1907. The act of 1910 adopts a project for obtaining—by about 10,750,000 cubic yards of dredging, 300,000 cubic yards of rock removal, and the construction of training walls—a channel to Jacksonville 30 feet deep by 300 feet wide, estimated to cost $2,852,000.

MOBILE HARBOR

Before improvement, the channel to Mobile had an available depth of only 8 feet. By 1880, a depth of 13 feet had been obtained. In 1909, a draft of between 23 and 24 feet could be carried over the shoalest part of the dredged channel in Mobile Bay, while over the bar at the entrance to the bay the depth ranged from 30 to 35 feet where before improvement there was only 23 feet. The dredged channel up to Mobile is 33 miles long. Since 1899, more than 15,000,000 cubic yards of dredging has been done and many snags and logs have been removed. The new project adopted by the 1910 River and Harbor Act provides for a channel 27 feet deep, 200 feet wide in Mobile Bay and 300 feet wide in the river, with a turning basin at the upper end. This will require dredging amounting to about 23,000,000 cubic yards. It is estimated that, including the cost of construction of two new hydraulic pipe-line dredges, the cost will be about $1,800,000. It is expected that export business will increase with an improved channel and heavy shipments of coal will probably result from the completion of the canalization of the Black Warrior, Warrior, and Tombigbee rivers, which work, involving the construction of 19 locks and dams, will probably be completed within a few years. These will carry a least depth of 6 feet from the coal fields in northern Alabama to Mobile Bay.

OAKLAND HARBOR

Oakland Harbor, California, is a tidal slough or channel opening into San Francisco Bay and lying between the cities of Oakland and Alameda. Before improvement it had a depth at the entrance of only 2 feet at mean lower low water. It has been improved by dredging, by the construction of jetties to connect the channel with deep water in San Francisco Bay, and by digging a tidal

flushing canal from the head of the slough to connect with San Leandro Bay. The total water frontage of the channel is about 7 miles, and the commerce in 1908 was about 3,600,000 tons. For a distance of about 5 miles from San Francisco Bay a channel 25 feet deep by 300 feet wide has been dredged up to a tidal basin, certain portions of the length having been widened. Considerable dredging has also been done in the tidal basin, the total length of the navigable portion of the channel being about 7 miles. While the facilities already provided have been of great value, the depth is not yet sufficient for large ocean vessels. Situated on the eastern shore of San Francisco Bay, in a convenient position for ocean and railroad terminals, the commerce of the port will undoubtedly develop rapidly if the navigable depths are suitably increased. The new project provides for a channel 30 feet deep and 500 feet wide up to the tidal basin, 25 feet deep and 300 feet wide around the basin, and for an increase in depth in the tidal canal from 8 feet to 18 feet, retaining its present width of 400 feet. This work is estimated to cost about $1,100,000.

LOS ANGELES HARBOR

The city of Los Angeles, Cal., has increased in population by 200 per cent in the last ten years, having now a population of about 300,000. It is situated about 20 miles from the towns of San Pedro and Wilmington, which are located near the seashore. Harbor improvement work has been carried on by the Government at the two latter localities. A stone breakwater nearly 2 miles long has been built to afford a harbor of refuge for deep draft vessels and to shelter the harbor of San Pedro. This work required the placing of about 2,500,000 tons of stone and cost about $2,900,000. Opening out into San Pedro Bay is Wilmington Lagoon. Before any work of improvement was done by the Government there was only 2 feet available depth in the entrance to the lagoon at low tide. The entrance channel has been dredged to a depth of 21 feet and jetties have been built to protect the entrance. The channel, up to the wharves at San Pedro (a distance of about a mile from the entrance), has been dredged to a depth of 24 feet and a width of 400 feet. A channel 25 feet deep has been excavated for a mile beyond the wharves toward Wilmington to a turning basin 1,600 feet in diameter, the excavation of which is practically completed to a depth of 24 feet. There is great interest in harbor development in this region, and recently Los Angeles, San Pedro,

and Wilmington have been consolidated under the name of Lo
Angeles; it is understood to be the intention of the city authori
ties to do all in their power to make the harbor one of the finest i
the world. Although the lagoon in which the main inner channe
and turning basin have been excavated and in which other im
provements are proposed is a tidal slough with a depth of water a
low tide in the unimproved portions averaging probably about
foot, harbor lines have been established by the Government to mar
out the limiting lines for all wharf extensions and channel improve
ments in the future. The completion of the entire amount of ex
cavation contemplated will probably take many years, but eventu
ally this will be one of the greatest harbors in the country. Al
ready the commerce for one year is valued at about $25,000,00
and the harbor has been used by vessels drawing 24 feet.

The act of 1910 provides for deepening to 30 feet those portion
of the inner harbor of Los Angeles which have already been im
proved, and for the excavation of additional channels each 20 fee
deep and 200 feet wide, one extending into the adopted locatio
for the future "East Basin" and one into the future "Wes
Basin." The San Pedro breakwater, which commences at th
24-foot contour about 600 yards from shore, will be extended t
the shore, thus affording increased protection to the outer harbo

SAULT STE. MARIE LOCKS

On the Great Lakes many important improvements have bee
completed and others are already under way under authorit
granted in previous river and harbor acts, notably that of 190
Included in this category is the new canal and fourth lock in th
rapids of the St. Marys River at Sault Ste. Marie, Mich. Th
new lock will be 80 feet wide by 1,350 feet long, with a depth
25 feet over the miter sills. It will be connected at the upper en
with the river above the rapids by a separate canal to be excavate
mainly in rock to a width of 300 feet. The cost of this new loc
and canal will be about $6,200,000. The act of 1907 either appr
priated or authorized the total amount required for this work.

THE DETROIT RIVER

In 1907, the Detroit River carried a commerce of 71,226,895 ton
This large commerce has been rendered possible by the improv
ments made in the lower portion of the river and elsewhere throug
out the Great Lakes. Before improvement, there existed in th

river a depth of only 12½ feet over a rocky ridge at Limekiln Crossing. A great deal of rock has been removed from this portion of the river and a depth of 20 feet can now be counted upon. The recent project provides for two channels—an upbound channel and a down-bound one—in the portion of the river near Bois Blanc Island; the upbound channel, which skirts the Canadian shore, is to be 21 feet deep by 600 feet wide, while the down-bound channel on the opposite side of the Island was to be 22 feet deep by 300 feet wide in the rocky portion and 800 feet wide where the river joins Lake Erie.

The act of 1910 provides for widening the down-bound channel where it passes through rock from 300 feet to 450 feet and for the construction of a dike extending northward from Bois Blanc Island, designed to separate the channels and prevent cross currents. This additional work will cost about $630,000.

ASHTABULA HARBOR

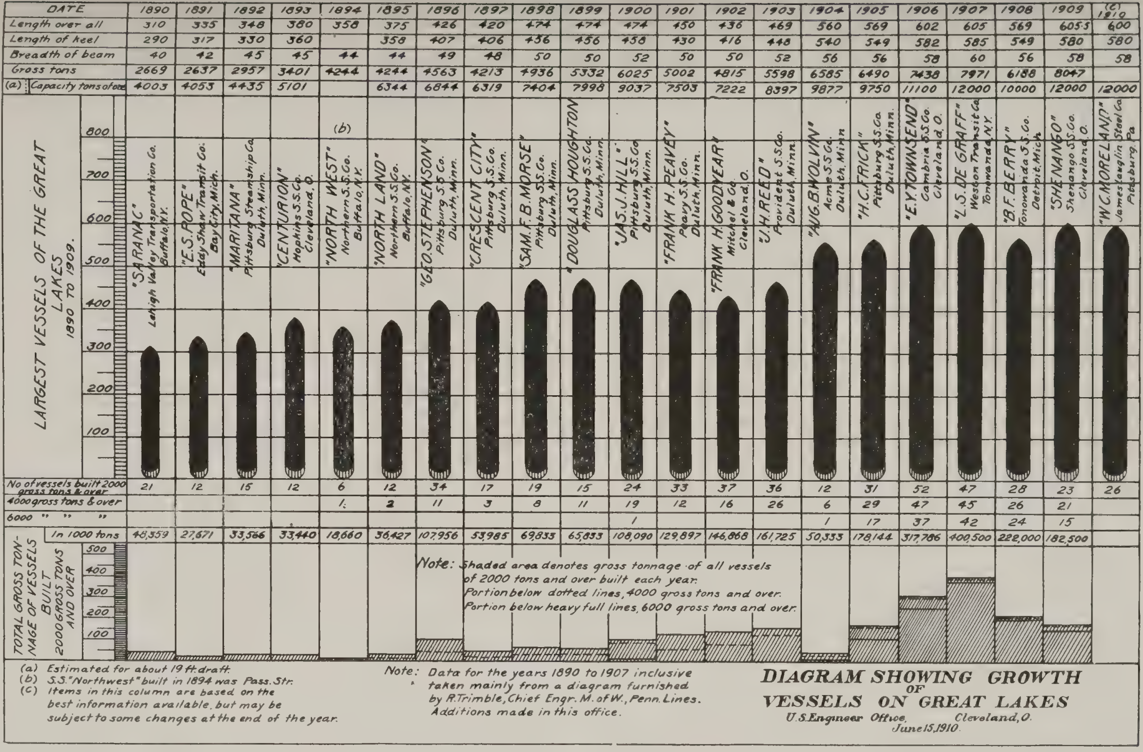
The commerce of Ashtabula, Ohio, for 1909 amounted to 13,178,172 tons, consisting principally of iron ore from the Lake Superior region and coal and steel products from the Pittsburg region. In its natural condition there was never more than 9 feet of water over the bar at the mouth of the Ashtabula River, the only ''harbor'' being inside the mouth of the river. Parallel jetties have been built out into the lake, one on each side of the mouth of the river. Converging breakwaters have been built outside to protect the entrance to the channel between the jetties, and considerable dredging and rock removal has been done. The channel at the mouth of the river is now at least 20 feet deep. These improvements have caused the tonnage to double within the last ten years. The breakwaters are detached from the shore and some trouble has been had because the currents alongshore tend to cause filling in the harbor and also make it difficult for large vessels to enter the channel between the jetties. The act of 1910 adopts a project which includes the extension of the west breakwater to shore and 1,700 feet farther lakeward. A new easterly breakwater, 5,400 feet long, will be built with an entrance channel 600 feet wide separating the adjacent ends of the two breakwaters. The breakwaters will be of the rubble-mound type. The new work will cost about $1,385,529. It will create a splendid outer harbor for Ashtabula.

CONNEAUT HARBOR

Conneaut, Ohio, is another lake harbor which has been well provided for by the recent River and Harbor Act. This harbor is about 70 miles east of Cleveland, and the harbor proper is formed by the lower part of the Conneaut River. Before the Government commenced the work of improvement, the depth over the bar at the mouth of the creek was only 2 feet. This has been deepened to 20 feet, parallel jetties have been built to protect the entrance channel, and two detached converging breakwaters have been built to protect the entrance to the jetty channel. As is the case at Ashtabula, difficulty has been had at Conneaut from sand carried along the shore tending to fill the channel inside of the detached breakwaters. Moreover, additional room is required in the outer harbor in order that large vessels may turn before leaving the protection of the breakwaters. The project adopted by the act of 1910 provides for extending the east breakwater to shore and lakeward for a distance of 800 feet. From a point 600 feet west of the new outer end of the east breakwater, a west breakwater is to be built extending in a westerly direction 1,000 feet and then in a southwesterly direction 3,700 feet toward the shore. The present small western breakwater will be removed and, when necessary, portions of the outer harbor will be dredged. The commerce of Conneaut amounted to about 8,350,000 tons in 1907 (principally iron ore and coal), and there seems little doubt that the increased facilities will be taken advantage of by a growing commerce. The estimated cost of the new work is $1,338,681.

LORAIN HARBOR

Where Black River flows into Lake Erie, 25 miles west of Cleveland is situated the city of Lorain. This is an important shipping point for coal and receiving point for ore from the Lake Superior region. The bar at the mouth of the river had a depth of water before improvement of only 3 feet. Parallel jetties have been built to concentrate the currents from the river on the bar and to protect the channel from filling due to alongshore currents, and dredging has been done to aid the river currents in securing increased depth on the bar. There is now a depth of 21 feet where the bar formerly existed and a depth of 20 feet can be carried for 3 miles up the river to a turning basin. Two converging rubble-mound breakwaters have been built to protect the entrance. Between the outer ends of the breakwaters is an opening 500 feet



DATE	1890	1891	1892	1893	1894	1895	1896	1897	1898	1899
Length over all	310	335	348	380	358	375	426	420	474	474
Length of keel	290	317	330	360		358	407	406	456	456
Breadth of beam	40	42	45	45	44	44	49	48	50	50
Gross tons	2669	2637	2957	3401	4244	4244	4563	4213	4936	5332
(a) Capacity tons of ore	4003	4053	4435	5101		6344	6844	6319	7404	7998
LARGEST VESSELS OF THE GREAT LAKES 1890 TO 1909.	"SARANAC" Lehigh Valley Transportation Co. Buffalo, N.Y.	"E.S. POPE" Eddy Shaw Transit Co. Bay City, Mich.	"MARITANA" Pittsburg Steamship Co. Duluth, Minn.	"CENTURION" Hopkins S.S. Co. Cleveland, O.	(b) "NORTH WEST" Northern S.S. Co. Buffalo, N.Y.	"NORTH LAND" Northern S.S. Co. Buffalo, N.Y.	"GEO. STEPHENSON" Pittsburg S.S. Co. Duluth, Minn.	"CRESCENT CITY" Pittsburg S.S. Co. Duluth, Minn.	"SAM. F. B. MORSE" Pittsburg S.S. Co. Duluth, Minn.	"DOUGLASS HOUGHTON" Pittsburg S.S. Co. Duluth, Minn.
No of vessels built 2000 gross tons & over	21	12	15	12	6	12	34	17	19	15
4000 gross tons & over					1	2	11	3	8	11
6000 " " "										
TOTAL GROSS TONNAGE OF VESSELS BUILT 2000 GROSS TONS AND OVER — In 1000 tons	48,359	27,671	33,566	33,440	18,660	36,427	107,956	53,985	69,833	65,833

DATE	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	(c) 1910
Length over all	474	450	436	469	560	569	602	605	569	605.5	600
Length of keel	458	430	416	448	540	549	582	585	549	580	580
Breadth of beam	52	50	50	52	56	56	58	60	56	58	58
Gross tons	6025	5002	4815	5598	6585	6490	7438	7971	6188	8047	
(a) Capacity tons of ore	9037	7503	7222	8397	9877	9750	11100	12000	10000	12000	12000
LARGEST VESSELS OF THE GREAT LAKES 1890 TO 1909.	"JAS. J. HILL" Pittsburg S.S. Co. Duluth, Minn.	"FRANK H. PEAVEY" Peavy S.S. Co. Duluth, Minn.	"FRANK H. GOODYEAR" Mitchel & Co. Cleveland, O.	"J. H. REED" Provident S.S. Co. Duluth, Minn.	"AUG. B. WOLVIN" Acme S.S. Co. Duluth, Minn.	"H. C. FRICK" Pittsburg S.S. Co. Duluth, Minn.	"E. Y. TOWNSEND" Cambria S.S. Co. Cleveland, O.	"L. S. DE GRAFF" Weston Transit Co. Tonowanda, N.Y.	"B. F. BERRY" Tonowanda S.S. Co. Detroit, Mich.	"SHENANGO" Shenango S.S. Co. Cleveland, O.	"W. C. MORELAND" Jameslaughlin Steel Co. Pittsburg, Pa.
No of vessels built 2000 gross tons & over	24	33	37	36	12	31	52	47	28	23	26
4000 gross tons & over	19	12	16	26	6	29	47	45	26	21	
6000 " " "	1				1	17	37	42	24	15	
TOTAL GROSS TONNAGE OF VESSELS BUILT 2000 GROSS TONS AND OVER — In 1000 tons	108,090	129,897	146,868	161,725	50,333	178,144	317,786	400,500	222,000	182,500	

Note: Shaded area denotes gross tonnage of all vessels of 2000 tons and over built each year. Portion below dotted lines, 4000 gross tons and over. Portion below heavy full lines, 6000 gross tons and over.

(a) Estimated for about 19 ft. draft.
(b) S.S. "Northwest" built in 1894 was Pass. Str.
(c) Items in this column are based on the best information available, but may be subject to some changes at the end of the year.

Note: Data for the years 1890 to 1907 inclusive taken mainly from a diagram furnished by R. Trimble, Chief Engr. M. of W., Penn. Lines. Additions made in this office.

DIAGRAM SHOWING GROWTH OF VESSELS ON GREAT LAKES

U.S. Engineer Office, Cleveland, O.
June 15, 1910.

wide in prolongation of the channel between the jetties. The river is narrow, and in order to turn and leave the harbor bow-on vessels have to go all the way up to the turning basin or else have to leave the river stern-first and then turn after leaving the channel between the jetties. This is difficult at times because of the currents which flow past the ends of the jetties, the breakwaters not having been carried to the shore. Moreover, the currents interfere with vessels entering the narrow channel between the jetties after they have safely entered between the outer ends of the breakwaters. The new project for Lorain provides for extending the west breakwater 1,500 feet to shore, for prolonging the east breakwater toward shore a distance of 800 feet, and for dredging in the protected area behind the breakwaters. The breakwaters will be of the rubble-mound type. This work is estimated to cost $248,000.

THE OHIO RIVER

Up to the present the work of improvement of the Ohio River has been carried on by two methods: *first*, open-channel work, and *second*, canalization.

The open-channel work on the Ohio River has included improvement by means of dredging, construction of wing dams to concentrate the flow over shoals, dams to close side-channels, snagging, removal of wrecks, rocks, etc. This work has been done throughout the length of the river between Pittsburg and Cairo, a distance of 967 miles. The condition of the river with respect to snags before improvement began is indicated by the following extract from a memorial of the citizens of Cincinnati to the 28th Congress:

> "The Ohio River, though not obnoxious to the full force of the sarcasm of the distinguished Virginian who described it as frozen one-half of the year and dried up during the remainder, is subject to vicissitudes which seriously affect the navigation and demand the National attention, from the double consideration of the magnitude of the evil and the vastness of the means required for its correction.
>
> "Throughout the winter the frequent changes from cold to moderate weather produce rains and thaws which occasion a series of freshets and afford ample supplies of water. The change from the severe cold of the winter to the higher temperature of the spring is usually sudden, and causes the precipitation of vast floods into the channels of our rivers. The snows which cover the Allegheny Mountains along their whole western exposure, from the borders of New York to those of North Carolina, are rapidly melted, and the whole of this mass of water is thrown suddenly into

the Ohio, which now attains its greatest depth and volume. In the great rise of 1832 the water rose at Cincinnati 63 feet above low-water mark; the sectional area was 91,464 feet, without including its extension over the lower part of Cincinnati and Covington; the number of cubic feet discharged per hour was 2,998,529,714 and the velocity of the stream was 6½ miles per hour.

"One of the important consequences of these great floods is the creation of obstructions in the form of logs and trees, which are swept from the bank and precipitated into the stream. The snags which cause the destruction of so many boats are formed of large trees, which are thrown into the channel by the crumbling of the banks or the force of the current.

"For several years past the appropriations for the snagboats have been so small as to render that service wholly inefficient; and the snags have accumulated with fearful rapidity in all the western rivers, while the increasing amount of commerce and number of boats have swelled the danger and the losses to an appalling extent. In the memorial of the citizens of St. Louis, recently published, it is stated that in the year 1839 there were 40 steamboats lost, 41 in 1840, 29 in 1841, and in the year 1842 the number is said to be 28, making a total in four years of 138 boats. The estimate here given for the latter year is far short of the truth, for since the date of this memorial at least 15 steamboats have been lost; indeed, while preparing this memorial, a single mail from the Southwest brought intelligence of the loss of 5 boats, 4 more were added to the melancholy list on the following day, and 3 more by a subsequent arrival.

"Between the 11th of September and the 15th of October, in the year 1842, the losses on the Mississippi, between St. Louis and the mouth of the Ohio, a distance of only 180 miles, were $234,000. Within the succeeding seventeen months there have been lost 72 steamboats, worth $1,200,000, besides their cargoes, which were of great value.

" * * * If to this be added the losses from the same cause on which there was no insurance, the amount would be not less than $1,000,000 per annum.

"The most fruitful causes of these losses are the snags, a species of obstructions which we have shown to be completely within the control of the Government; and we therefore respectfully urge the propriety of an immediate and energetic action by the Government in reference to this subject, by the construction of as many snagboats as may be necessary, and an annual appropriation for keeping these boats in the regular service of the Nation from year to year."

The work done on the general improvement of the river has been of great value, but navigation is entirely suspended during certain seasons of the year because of low water. In addition to the open-channel improvement, certain locks and dams have been

built. They are numbered from the head of the river, and up to date Dams Nos. 1 to 6 have been completed, except in minor particulars, furnishing slack-water navigation with a least depth of 9 feet over the first 30 miles of the river below Pittsburg, that portion in its natural condition having been the worst section of the river. At present there are under construction seven other dams, namely: No. 8, near East Liverpool, Ohio; No. 11, at Wellsburg, W. Va.; No. 13, just below Wheeling; No. 19, below the mouth of the Little Kanawha; No. 26, below the mouth of the Great Kanawha; and No. 37, just below Cincinnati. It is expected that Nos. 8, 11, and 13 will be completed during the present year. No. 18, just below Marietta, has recently been put in operation.

The act of 1910 adopts a project for the Ohio River which involves the canalization of the entire length of the river by means of 54 locks and movable dams, so located as to provide a least depth of 9 feet in the pools.

In order to complete the improvement of the river as contemplated by the project above mentioned, there will be required 41 locks and dams in addition to those at present completed or under construction. The amount necessary to complete the 41 locks and dams just mentioned is estimated at $57,566,800. In order to complete the locks and dams now under construction there will be required $3,213,800 in addition to the amounts already authorized, making a total of $60,780,600 to complete the 9-foot project for the Ohio River.

The work to be done at Louisville is of great importance, irrespective even of the improvement of the river as a whole. The work proposed at this place includes the widening of the present canal and the construction of a new lock, 85 feet wide by 600 feet long.

The upper portion of the river is by far the worst for navigation. While in the vicinity of Wheeling the river is at a natural stage above 9 feet on only about one hundred and twenty days of the year, it is at a stage of at least 9 feet on about two hundred and forty days in each year between Cincinnati and Louisville. For this reason the act provides for the beginning of construction of Locks and Dams Nos. 7, 9,10, and 12,which, in conjunction with the dams already completed or under construction, will complete the canalization of that portion of the river between Pittsburg and Wheeling.

In past appropriation acts provision has been made for the con-

struction of various individual locks and dams, located below the mouths of important tributaries or below important cities to form harbors of considerable local importance. In accordance with this policy the 1910 act provides for the commencement of construction of Locks and Dams Nos. 29 and 48, the former being located below the mouth of the Big Sandy River, which has already been partially canalized by the Government, and the latter being located below the mouth of Green River, which has also been canalized by the Government. These two dams will therefore afford a navigable connection between the Ohio and the tributaries named. No. 29 will also provide a harbor for Catlettsburg, Ky., and Kenova, W. Va., while No. 48 will provide a harbor for Evansville, Ind., and Henderson, Ky.

The Ohio River locks are each 110 feet wide by 600 feet long, and will pass 12 coal boats at one lockage. The dams are about 1,100 feet long just below Pittsburg, and this length will not be much increased in the portion of the river above Cincinnati. The principal portions of the dams will be composed of Chanoine wickets supported in the raised position by props. The dams will each be provided with one or more regulating weirs of the common two-leaf bear-trap variety.

The present act adopts the Ohio River canalization project ''with a view to the completion of such improvement within a period of twelve years.'' In order that the work may be completed in the time specified, it will be necessary for the funds to be furnished as needed and this is understood to be the intention of Congress.

THE MISSOURI RIVER

On the Missouri River the first work included snagging and bank protection work at various localities. In 1884, the work was undertaken in a serious manner and was placed under the immediate charge of the Missouri River Commission, reporting to the Chief of Engineers. The Commission selected the worst stretch of the river and by dike construction and revetment secured a continuous channel at least 6 feet deep at low water where before improvement the depth had been only 2½ feet. The length of the river thus improved was 45 miles in the vicinity of Jefferson City, Mo. The works have remained in fairly good condition with small expenditures for maintenance, and this stretch of the Missouri River is practically the only part in which a good continuous navigable channel can be found at low water. Moreover, the dikes and

revetments have reclaimed land equal in value to the cost of the improvements. In 1902, the Missouri River improvement was practically abandoned by Congress, and since then the appropriations had been too limited to permit of any systematic work. The funds have had to be applied to work at widely separated localities in order to improve conditions at the worst bars and revet the worst of the caving banks as far as was possible with the small amounts available. The act of 1910 appropriates $1,000,000 for work between Kansas City and the mouth of the river, to be applied to securing a 6-foot channel. The act also provides for a report by a board of officers upon the subject of coöperation by local interests in the work of improvement. It is thought that this is designed to ascertain whether or not some method can be devised whereby the property owners whose lands are protected by the Government dikes and revetments can be caused to pay an equitable portion of the cost of improvement. The work done on the Missouri River has been eminently successful wherever funds were available in sufficient amounts, and the results demonstrate that it is possible to adequately improve the lower portion of the river for purposes of navigation at a reasonable cost.

THE UPPER MISSISSIPPI

On what is generally called the Upper Mississippi River, that is, the portion of the river between St. Paul and the mouth of the Missouri River, the first regular improvement work undertaken was the removal of wrecks, snags, etc. This work has been prosecuted since 1867, with the result that danger from them is practically a thing of the past. In 1877, a lateral canal around the Des Moines Rapids was completed. The canal is 5 feet deep and 200 feet wide, with three locks. Originally, the larger boats were unable to go farther upstream at time of low water than La Crosse or Winona. Since 1878, the systematic improvement of the river has been carried on. The project adopted in 1878 contemplated the securing of a channel at least 4½ feet deep as far up as St. Paul by contracting the channel with wing dams, closing of side-channels, revetting banks, etc. The work has been quite successful although not yet completed, large boats being now able to proceed to St. Paul at very low stages of the river. The reservoirs constructed at the headwaters of the river increase the low water depths at St. Paul, on the average, about 14 inches during the low

water season of ninety days. The effect of the reservoirs disappears at Lake Pepin, 51 miles below St. Paul.

In 1907, a project was adopted which looks to the obtaining of a least depth of 6 feet throughout this section of the Mississippi. This is to be done by methods similar to those already followed with success, the general idea being that a further narrowing of channels will increase the depth still more. The project includes also a lateral canal around the Rock Island Rapids, and a certain amount of auxiliary dredging. The estimate of cost of this project is $20,000,000. The act of 1910 provides that the work shall be so conducted as to complete it within twelve years.

THE MIDDLE MISSISSIPPI

The Mississippi River between the mouths of the Missouri and Ohio rivers originally had a channel depth of only 3½ to 4 feet at low water. The portion between St. Louis and Cairo, a distance by river of 182 miles, is characteristic of a river with shifting bed and caving banks, and in this respect it differs greatly from that portion of the Mississippi River above the mouth of the Missouri. In fact, the conditions as to stability of bed are like those of the Missouri.

In 1881, a systematic improvement of this portion of the river was commenced with a view to obtaining a least depth of 8 feet under a project which contemplated the confining of the channel to a width of 2,500 feet at bank-full stage by closing side-channels and causing the building out of new banks by permeable dikes so constructed as to cause a deposit of material by slackening the water currents, and the revetting of old and new banks wherever necessary. Since the date of the adoption of this project, it has been extended to include dredging, and in recent years the annual appropriation has been little more than enough to provide for the dredging necessary to keep open a channel during times of low water. This dredging has been done so effectively that for several years a channel with an 8-foot depth has been maintained between St. Louis and Cairo throughout the navigation season with only occasional interruptions of a day or two. However, the channels are constantly shifting in position and until the complete regularization contemplated by the present project is completed, the improvement can not be considered as satisfactory. Although much remains to be done to complete the project, much has already been accomplished. Seventy-one miles of banks have been protected by

hurdles and 60 miles have been protected by revetment. This work has materially decreased the amount of bar-making material which comes from caving banks. While between 1879-1889 an average amount of 64,000,000 cubic yards of earth fell into the river from caving banks annually between St. Louis and Cairo, the average amount for the years 1899-1907 was 49,500,000, the decrease being due to the revetment work done between 1881 and 1905.

The act of 1910 appropriates $500,000 for continuing the improvement of this portion of the Mississippi along the lines of the present project, and adopts the policy of completing the improvement within a period of twelve years.

THE LOWER MISSISSIPPI

The Mississippi River Commission has been in immediate charge of the improvement of the Mississippi between the mouth of the Ohio and the head of the Passes, and the surveying and gauging of the river throughout its length. The Commission was organized in 1879, pursuant to Congressional action. It is composed of three officers of the Corps of Engineers and four civilians, with an additional Engineer officer as secretary to the Commission. The act creating the Commission directed it to mature plans for preventing destructive floods as well as for facilitating navigation. The original project of the Commission, which was adopted by Congress in 1881, provided for narrowing the low-water channel to about 3,000 feet by dikes, the revetment of caving banks, and the construction of levees to confine the flood waters within the river bed. Later acts of Congress authorized the use of hydraulic dredges to obtain a channel 9 feet deep and 250 feet wide, and authorized the building of levees above the mouth of the Ohio as far up as Cape Girardeau.

The Mississippi below the mouth of the Ohio flows through a thick alluvial bed and is similar in characteristics to the portion above Cairo. However, all features are on a grander scale. The difficulties of navigation are due to the changing and shallow channels caused by the shifting of the bed of the river and the caving of the banks. The amount of caving is very great. At one place it has amounted to a cutting of the bank back for 500 feet in three months, and at another to a cutting of 1½ miles within ten years. The depth of erosion sometimes is as much as from 30 to 140 feet below low-water level in the portion of the river now

under consideration. Measurements made in 1892 indicated that about 1,000,000 cubic yards per mile annually fell into the river from caving banks between Cairo and Donaldsonville, La., while measurements made in 1908 showed that between Cairo and Red River there were 749 miles of caving banks along a channel 790 miles long. Until the caving of banks is stopped, there can be no permanent improvement of the navigable condition of the river, and until the banks are securely held in position proper terminal facilities can not be established.

Much revetment work has been done in the past, but at present the work of this nature is mainly for the revetment of places where important levees or harbors are threatened. The revetment generally used consists of continuous submerged mattresses, with riprap bank protection above low water.

The levees along the river have been built by private property owners, by the States and by the Federal Government. In the floods of 1882-1884, before work was done by the Mississippi River Commission, the overflowed area was about 29,740 square miles, while in 1903 it was only 6,820 square miles, the difference being due to the levees built in the meantime. The system now includes 1,486 miles of levees. These levees held the floods of 1907 and 1908 so that the territory overflowed was of insignificant area.

The ten hydraulic dredges used in the river below Cairo are now depended upon to keep open the 9-foot channel and they have done so during recent years, except for very short periods.

For the Mississippi River below Cairo, the act of 1910 appropriates $2,000,000 and provides for a continuance of the work already begun with a view to securing a permanent channel 9 feet deep within a period of twenty years. In addition to the amount mentioned the Sundry Civil Act of 1910 carries an appropriation of $2,000,000 previously authorized, making a total of $4,000,000 available for the Mississippi River Commission work.

THE CUMBERLAND RIVER

The Cumberland River is navigable for light-draft steamboats about half of each year as far up as Burnside, Ky., 518 miles above the mouth of the river, and 326 miles above Nashville. The river has been improved by the removal of snags, gravel bars and rock ledges, by the confining of the low-water channel to proper limits by means of wing dams, training walls, etc., and by the construction of locks

and dams. Two locks and dams have been built below Nashville, Lock A located 41 miles, and Lock No. 1, two miles below that city. The former drowned out a very obstructive shoal and lengthened the period of useful navigation below Nashville by about two or three months per year. Above Nashville there have been completed Locks and Dams Nos. 2, 3, 4, and 5. Nos. 6 and 7 will be completed in the near future and will carry a 6-foot depth to Carthage, 116 miles above Nashville; the eight dams providing a least navigable depth of 6 feet over about 157 miles of the river. However, this continuously navigable portion is separated from the Ohio River by a portion about 150 miles long in which, for about four months of each year, it is impracticable to carry on a profitable navigation. A project for the canalization of the greater part of the distance between Lock A and the mouth of the river was adopted by the recent River and Harbor Act. Five locks and dams, known as Locks B, C, D, E, and F, are to be built below Lock A at a cost estimated at $3,066,122. These dams are to be of the fixed type and will be of timber cribs with concrete tops. The locks will be 52 feet wide by 280 feet in available length with 6-foot depth on the sills, thus providing for four standard coal barges at one lockage. The average lift of the dams will be 12 feet. The portion of the river, about 50 miles in length, below the lowest projected lock will be improved by dredging a 6-foot channel 150 feet wide through the obstructive bars at a cost estimated at $98,760. The funds appropriated and authorized by the 1910 act amount to $663,000, which will be applied to purchase of land required for Locks B, C, D, E and F, and toward the construction of Locks B and C.

PUGET SOUND-LAKE WASHINGTON WATERWAY

The 1910 act makes provision for substantial progress in the construction of the Puget Sound-Lake Washington Waterway. This improvement has been under consideration for many years and several surveys have been made of the route of the waterway. However, because of lack of funds, not much progress has been made. Lake Union lies about 4 miles east of Puget Sound and within the limits of the city of Seattle, while Lake Washington lies east of Lake Union and separated from it by a strip of land about 2,000 feet wide. A channel at least 10 feet deep has been excavated by the Government from Puget Sound for a distance of about 2 miles to the Ballard bridges at the head of Salmon Bay;

within 2 miles of Lake Union. However, neither Lake Union nor Lake Washington is at present connected with Puget Sound by any navigable waterway.

Lake Union has a depth of at least 40 feet over an area of about 500 acres, while Lake Washington is about 19 miles long by 2 miles wide. The new project contemplates the excavation of a channel across the neck of land separating the lakes and the lowering of Lake Washington to the level of Lake Union; the excavation of a canal 25 feet deep by 75 feet bottom width from Lake Union to the western end of Salmon Bay, where will be located a double lock to form the connection between the Lake and Sound levels; and enlargement of the channel leading from the lock site to Puget Sound. The lock chamber will be 80 feet wide by 825 feet long with a depth on the sills of 25 feet at extreme low tide. Alongside the large lock a smaller one, 30 feet by 150 feet, with 16 feet on the sills will be built. The plans contemplate also the construction alongside of the locks of a power plant and works to regulate the level of the lakes. The power plant will furnish about 1,000 horsepower in addition to the amount needed by the Government, and it is the intention that the plant will be leased by the Government, thus being a source of continuous revenue. The work will result in the formation of a single fresh-water harbor with a shore line about 100 miles in length. At present Elliott Bay, an arm of Puget Sound, is used as the harbor of Seattle. The new harbor will possess certain advantages over the present one, among them being the absence of salt water and marine life, the greater ease of wharf construction due to less depth of water, the absence of tidal oscillation, and the greater wharfage space available. The projected work is estimated to cost $3,554,932. A local assessment district has been formed to coöperate with the United States in this work, and the work to be done by the United States will include only the construction of the lock and accessory structures, and the enlargement of the channel between it and Puget Sound, the limit of cost of the Government work being $2,275,000.

Mr. A. J. Nolty

United States Assistant Engineer

1845-1910

Mr. August J. Nolty, United States Assistant Engineer, was born January 1, 1845, in Saxony, Germany, and came to this country with his parents about 1850. He enlisted, while yet a boy, as a private in Company D of the Eighty-fourth New York Volunteers, and served during the latter part of the Civil War.

After being mustered out, he enlisted in the Battalion of Engineers, then stationed at Willets Point, and continued his services in that Battalion until 1876, when he became engaged upon the river and harbor work under the Chattanooga office, then in charge of the late Gen. William R. King. In 1880, he married Miss Amelia Schneider of Chattanooga, Tenn. After six years of service in the Chattanooga District, he was transferred to the Mississippi River, and during the last twenty-eight years of his life he was intimately connected with every phase of the river improvements in the 400 miles of river below Cairo, Ill.

Many of the methods and much of the success of the work must be attributed to Mr. Nolty; every detail of plant and methods was intimately known to him, as were also the characteristics of the river throughout the section mentioned. He was successively promoted in the service, and during the later years of his life was the Principal Assistant Engineer of the Memphis District.

A practical, self-made man and engineer, he, by his application and native ability, made for himself a position in the Memphis District such that no plan was prepared and no method undertaken except after a full discussion with him. His judgment was so good and his energy and perseverence, even in the bad health of his later years, were so great that he left a personal impress upon the river work which will last for many years to come. He was a type of man whom it was hard to lose, and whose place it will be difficult to fill. It is to the honesty, faithfulness, loyalty, and ability of such engineers as Mr. Nolty that the public works under the Corps of Engineers owe a very large measure of their success. ''Peace has her victories no less renowned than war,'' and in both peace and war Mr. Nolty served his country faithfully and well, and helped win her victories in both.

AUGUST J. NOLTY
UNITED STATES ASSISTANT ENGINEER
1845-1910

GOVERNMENT SPECIFICATIONS FOR ELECTRICAL APPARATUS*

THEIR RELATION TO THE STANDARDIZATION CODE OF THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS AND TO MANUFACTURERS

BY

Mr. CHARLES F. SCOTT
Consulting Engineer, Westinghouse Electric Company

The story of the Atbara Bridge, which an American firm proposed to erect and actually did erect in less time than foreign manufacturers required for the completion of their drawings, is an international example of the American use of standards. The specifications called for the erection of a bridge of definite capacity, without including detail particulars. Had they not been broad enough to admit the American standards, the American bidders would have been excluded, or, rather, new designs, special materials and long delay would have been involved. We all know that American manufacturing has won its success because things are made in large quantities in standard sizes. It is reasonable, therefore, to expect that the policy of the American Government would be to follow the American method, by putting a premium upon standards, and standard specifications. The Government, as a large purchaser, should be the last to create a demoralizing interference in industrial methods by calling for things which are not standard, but involve special requirements and distinctions, often of little or no vital consequence. And yet cases may be cited in which the course pursued by the Government has fostered specialization and irregularity, often involving complication and higher prices with no compensating advantages.

EIGHT SPECIFICATIONS FOR INCANDESCENT LAMPS

As an instance of an extreme condition, and the way in which it was remedied, I cite the following statement which has been given me regarding incandescent lamps.

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*A paper read at the United States Engineer School, Washington Barracks, D. C. The paper is included in the course of instruction of the Department of Electrical and Mechanical Engineering of the Engineer School.

When the question of purchasing incandescent lamps in large quantities for the several departments of the Government was taken up and investigated about five years ago, it was found that the Treasury Department had one specification; the Bureau of Yards and Docks of the Navy another; the Bureau of Equipment of the Navy a third; the Quartermaster's Department a fourth; the Library of Congress a fifth; the Government Printing Office a sixth; the Post Office Department a seventh, and the Bureau of Engraving and Printing an eighth. While nearly all of the lamps were substantially the same and there were but few unusual requirements, yet no two of these specifications agreed, and great difficulty was experienced by the manufacturers in understanding just what type of lamp should be furnished under any one of them. To eliminate this difficulty the Bureau of Standards and the Government engineers of the several departments held a meeting in Washington to discuss the subject of standardization of specifications, and appointed a committee which met with a similar committee appointed by the incandescent lamp manufacturers. This joint committee drafted what is known as the Government standard specification, and to-day when one department of the Government requests proposals on standard specifications, they are the same as the specifications of any other department, except in isolated cases—for example, the Navy Department, which requires some special lamps. The standard specifications have eliminated a great deal of difficulty on the part of the lamp manufacturers and the Government engineers as well.

EXAMPLES OF UNSYSTEMATIC SPECIFICATIONS

A further illustration of the same kind is afforded by rubber-insulated wire. In this case, however, I am informed that the work has not yet been carried to completion. On the investigation of the specifications for standard rubber-covered wire, it was found that the Navy Department's Bureau of Equipment had one specification, the Navy Department's Bureau of Yards and Docks another, the Library of Congress another, the Treasury Department another, the Quartermaster's Department another, and there were perhaps one or two other peculiar specifications. On looking over these specifications, they ran a complete line from the poorest competition wire which would comply with the National Board of Fire Underwriters' manufacturing specifications to the most elaborate specifications for 36 per cent Para rubber insulation; not-

withstanding the fact that the wire was to be used under virtually identical conditions. In investigating this matter the question of wire for ship-board purposes was taken into consideration and it was found that, with few exceptions, all specifications for wire could be embodied under a few general heads.

A further instance which has been cited in the same connection is with regard to motors. When the question of specifications for motors was looked into, it was found that the same variance takes place in the specifications: for example, the temperature requirements of a motor covered the entire line from operation at full-load for an hour with a rise of 75° F., to operation continuously for twenty-four hours at 25 per cent overload with a considerably less rise of only 63° F. Such variance in the requirements for motors would apparently cause the manufacturer to make up special apparatus to comply with each specification.

As an example of the non-conformity of specifications and lack of coöperation, it may be cited that in one instance three bureaus were represented in the specifications for apparatus which was to be operated in conjunction, and in which controlling panels for various motors were to be installed in a single room or compartment. One of the bureaus specified a water-tight control panel; another, a switchboard enclosed in a nonwater-tight sheet-iron case, and the third entirely open panels. Three types of control apparatus were therefore to be installed in conjunction in the same compartment.

SOME SPECIAL FEATURES OF GOVERNMENT SPECIFICATIONS

It is easy to criticise and to show the absurdities of such divergence in specifications as are afforded by the foregoing instances. They certainly are not the result of any established policy, but are examples of certain practices which have grown up under past conditions. In discussing the subject, there are several features which should be considered:

1. The Government as a purchaser has, in many cases, prepared its specifications before suitable commercial standards were established and recognized. This was undoubtedly the case as regards lamps and wire. In the matter of rubber-covered wire, for example, one of the largest electrical manufacturing companies, which is an extensive user of such wire, found a few years ago such chaos in wire specifications and such divergence among the regular products of different wire manufacturers, that it was compelled to

make its own purchasing department specifications for rubber-covered wire. This was not done in an arbitrary way, but, by considering carefully the various standard makes and after consultation with the various manufacturers, a standard list was prepared which would meet the requirements and would impose a minimum inconvenience upon those who furnished the wire. Obviously, it is impossible for the Government to use standard specifications if there are no standards.

2. Another reason why Government specifications are apt to appear arbitrary and call for special apparatus is due to the tendency to enter into particulars and to do designing. It is hard for the engineer, Government or other, to restrict himself to general requirements and not yield to the temptation to enter into details which should concern only the designer of the apparatus. Ordinarily, the purchaser should not be the designer; or if he is, he must take the consequences in restricting competition, in uncertain deliveries, in the extra cost which such products usually involve, and he should properly share the responsibility for what he designs.

3. Apparatus may be specified to meet exactly certain definite requirements, although it may be entirely feasible to adapt or modify the conditions so that standard commercial apparatus may be used. For example, in designing a mechanical structure, it may be calculated that an I-beam of certain dimensions will exactly meet the requirements. If these are different from those of standard sizes, its manufacture would involve delay, inconvenience, and extra cost. On the other hand, the use of a standard I-beam would probably require only slight modifications in the conditions, or in the arrangements of other parts. Likewise, in arranging machines to be operated by a motor, it may be found that some odd horse-power at some unusual speed, or certain special forms or dimensions of bed plate or bearings happen to meet the exact requirements, whereas some slight modification in the arrangement might enable a standard motor to be employed. In some instances this can not be done, as new requirements justify special construction, but such cases are the exception. A demand for something special when that which is standard might be used, shows inferior rather than high engineering ability. The best engineer seeks to adapt his conditions so that he may utilize the things at hand, the standard products which are upon the market.

4. Some of the men who are called upon to prepare specifications have been trained in Government schools, and in Government

service, and have never had experience in manufacturing or commercial work, and hence they often do not have a first-hand technical and practical knowledge of the matters involved. Men who have not had a commercial training may not have developed the instincts of economy of the ordinary commercial engineer, and are more apt to yield to the temptation to specify what they want, regardless of what is available and regardless of cost.

5. Another alleged reason why Government specifications have not conformed to ordinary practice is that the Government officials are in a position of authority and are sometimes arbitrary, unyielding, and apt to be controlled by technicalities. It is quite likely, on the other hand, that Government officials have regarded the manufacturers as inordinately commercial, putting their individual interests far above engineering excellence or Government efficiency. But, whatever weight such considerations may have, it does not fall within the range of the present discussion to enter into personal criticism.

EXAMPLES AND CONSEQUENCES OF ARBITRARY ACTION

Some of the results of arbitrary action, however, both in the issuing of specifications and in the acceptance tests of apparatus, react upon the Government, and place it at a commercial disadvantage. Apparatus will cost more if, when inspected and tested, it is liable to be rejected on technicalities, for the manufacturer must charge extra to cover this liability, and in the long run manufacturers may decline to bid, thereby reducing competition. Much depends upon the spirit in which the specifications are interpreted. An ordinary business man, particularly when he asks for something in which the conditions are new, is satisfied if the specifications are approximated within a certain reasonable range, particularly if the essential and useful elements are satisfactory, and the apparatus accomplishes its purpose. But the Government inspector has the reputation of demanding his ''pound of flesh.'' As an example, a machine adapted for both alternating and direct current was sold to the Government. It was intended to state in the specifications that the alternating-current voltage should be ''approximately 70 per cent'' of the direct-current voltage, but a typographical error made the figure 73 per cent. The machine was not acceptable because the actual ratio was about 70 per cent. It was a matter impractical to change on account of certain inherent elements depending on the arrangement of the windings and the width of the field

poles, which proportions were selected in order to secure the best commutation and the best general performance of the machine. In this case, a general approximate descriptive statement (which was a typographical error) was interpreted as a rigid guarantee, and a variation from it was treated as if it were as serious as a failure of several per cent in efficiency. The operating excellence and adequacy of the machines were not questioned, but the miserable little matter of ratio caused long drawn-out annoyance, friction, and delayed payments.

In another case, certain small generators were supplied for shipboard operation, which on test were found to have a temperature rise which exceeded the specified limit by a few degrees. The apparatus, if rejected, would be of little or no value to the builder, as it was special. The outfits were eminently satisfactory, except in the trifling excess temperature. The inspector who made the test reported that they were the best machines he had ever seen, and were satisfactory, except in the one point of temperature. The actual temperature rise was a trifle more than the Government specification, but was less than ordinary commercial standard practice. The "pound of flesh" was exacted in the form of a penalty equal to nearly one-half the value of the generators, which turned a manufacturer's small profit into a large loss. The result was that the manufacturing firm which had thus been penalized has declined to make further bids when importuned to do so by this bureau.

In a certain specification for a machine for a special service, the specification contained a clause the meaning of which was not clear. Literally, it either meant nothing or specified a physical impossibility. A more liberal interpretation indicated a desirable and proper characteristic. The designer took the common-sense interpretation and did what was practical and useful. The machine met its acceptance test satisfactorily, except that it did not literally comply with the impossible requirements. The inspector declined to accept the machine. The matter was investigated. It was found that the original writer of the specifications did not know what the particular paragraph meant, but he had seen an attractive phrase somewhere and had incorporated it. The machine was finally accepted, but the conference between the inspector and his superiors had caused a delay in shipment and for this a penalty was incurred, which the manufacturing company had to pay.

FACTORS IN THE PREPARATION OF SPECIFICATIONS

It is easy to criticise specifications and tests and to cite past specific experiences as horrible examples of how things should not be done. It is also easy to demonstrate the value of standard specifications. It is quite another matter to prepare ideal specifications. This is especially true of electrical apparatus, where there must be constant evolution and development to keep up with increasing requirements and improvements in design. Commercial specification should form a definite basis for present work, but they should not restrict progress.

The whole matter of specifications for the purchase of material and apparatus is a complicated one. There are two sides to it, one concerning the user, the other concerning the manufacturer; first, what is necessary to perform the required service, and, second, what is commercially or practically available. The company with which I am connected is a large purchaser of materials. Many of these are ordinary commercial products, others involve special requirements on account of the uses to which they are put. We do not arbitrarily specify what we would like to have, but we consult freely with the manufacturers to determine how our needs can be best met by what they are in a position to furnish. We recognize that we are not experts in their products and we enter into conference with them, and in many cases results have been secured through conference and coöperation which could not otherwise have been attained. In a few cases, we have been accused of having scientific experts, who do not know the practical uses and essential qualities of the material, write up the specifications, using various scientific terms and proposing theoretical and scientific tests. Such a specification is usually modified by conference. Our real aim, however, is to write specifications which will provide a reasonable, practical measure of the ability of the material to meet the requirements for which it is to be used.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS STANDARDIZATION RULES

A number of years ago, the American Institute of Electrical Engineers recognized a confusion among manufacturers, consulting engineers, and users, which arose from imperfect standards. There was a topical discussion on the standardizing of generators and transformers at a meeting in January, 1898.

It was pointed out that while it would probably be impracticable to

establish definite sizes or lines of apparatus that would be satisfactory to all concerned, and while it should not be the object of the Institute to introduce standards which the evolution of business would soon render useless, yet there were certain features which could properly be taken up by the Institute, notably the definitions of terms used in specifications, uniform methods of rating apparatus, methods of conducting tests, etc. A committee was appointed and its report was issued in June, 1898. This report has been revised twice and was issued in its present form in June, 1907, as the "Standardization Rules of the American Institute of Electrical Engineers." Various matters relating to definitions of terms, performance specifications and tests, which may be adopted in general practice for making definite and uniform the specifications between manufacturers and purchasers, are presented in a simple, practical way. No attempt is made to dictate sizes, speeds, dimensions, and the like. The aim is to define what a specified load really means and how it should be measured; what elements are involved in efficiency and how they should be measured; what constitutes a reasonable rise in temperature and how temperature should be measured. These standardization rules have been proposed and revised by a large representative committee, including experts connected with Government bureaus, engineers from manufacturing companies, consulting and operating engineers and scientific experts. The rules have been submitted in preliminary form to expert engineers for criticism and suggestion. They therefore represent the best practice. The rules do not purport to be scientifically abstruse nor to cover all cases; for example, in connection with definitions, this note is given: "The following definitions and classifications are intended to be practically descriptive and not scientifically rigid;" and in connection with insulation tests: "The voltages and other conditions of test which are recommended, have been determined as reasonable and proper for the great majority of cases, and are proposed for general adoption, except where specific reasons make a modification desirable." It is common practice in commercial specifications and tests to follow methods laid down in these standardization rules. Incidentally, they are quite comprehensive in their scope and bring together in concise form a very large amount of engineering data and information. One man who read through the rules carefully, remarked that he felt that he had reviewed his whole college course.

ELECTRIC MOTOR SPECIFICATIONS

An admirable presentation of the elements which should enter into a commercial specification is contained in a paper presented to the American Association of Electric Motor Manufacturers by Mr. R. S. Feicht, chairman of its committee on Government specifications, in May, 1909. The subject is so well discussed that I shall quote at length from the paper.

''The purpose of motor specifications for large consumers is:

''1. To insure a uniform grade of apparatus of a satisfactory quality and performance.

''2. To enable the purchasing department to place orders for motors without the necessity of securing special engineering advice and with the assurance that the proper motors will be obtained for the particular applications involved.

''With these points in mind, let us see whether we can establish some of the important characteristics of an ideal set of motor specifications.

''1. They should be written in a clear concise manner so that there can be but one interpretation for each statement and no two parts should be in any way contradictory. These are particularly vital points, as the specifications are made up for the use of the motor manufacturer and the representative of the customer, who are usually not consulted in writing the specifications, and, therefore, are not familiar with the intent of the specifications unless the wording of them is unmistakable.

''The use of such phrases as 'perfect mechanical balance,' 'without sparking,' and 'satisfactory operation' should be carefully avoided, as a literal interpretation of them may cause the rejection of any machine, however well designed and constructed. *Perfect mechanical balance* is attained by accident only. *Absolutely sparkless commutation* is practically impossible. *Satisfactory operation* depends entirely upon how easily the witness may be satisfied. It is not right that a manufacturer should be put to the expense of building a motor, the acceptance of which is entirely dependent upon the personal equation of a witness. The wording of the specifications should be such that the manufacturer will be in a position to know positively before the witness test is made that the motor will or will not meet the specifications in every particular.

''2. Ideal specifications should contain a general description which will permit the use of any well recognized standard apparatus for the purpose, thereby insuring competition in bids. They should be broad and liberal, so as to permit the usual variations in design. It should be recognized by the writer of the specifications that the future development of the motor depends upon variations in the present designs, and therefore unnecessary restrictions which serve no good purpose, but simply throttle development, should be avoided.

"3. Ideal specifications should either omit performance guarantees altogether and leave them to the bidder to supply, or should give them slightly lower than the average, preference being given in the awarding of the contract to motors with the highest performances, other things being equal.

"4. Ideal specifications should cover the tests which are to be made to determine whether the motor meets guarantees and, recognizing the unavoidable variations in workmanship and materials and with what degree of accuracy the tests can be made in a commercial testing room, they should specify within what limits the results of tests are to be considered as meeting guarantees.

"We often find in specifications for motors that certain points are covered which should obviously be omitted. In the following a few of these points are noted:

"Certain characteristics of a motor are at times specified which in themselves are of no particular moment, but which affect other characteristics covered by the guarantees. In other words, the end is specified in the guarantees and in addition the means of attaining the end are covered by general requirements. As an example of this feature, we often find in specifications that temperature guarantees are specified for full-load and overload, and, in addition, the question of ventilation is covered. Now, if the temperature guarantees are met, the question of inherent ventilating characteristics is of no importance whatever to the customer. Again some specifications cover efficiency guarantees very minutely, and, n addition, specify that the losses in the motor shall be a minimum or that the best grade of iron shall be used to minimize the losses, etc. Here also, if the efficiency guarantees are met, the question of osses and quality of material used are irrelevant and serve only to handicap the designer.

"Some specifications, though apparently written on a liberal and unprejudiced basis, distinctly discriminate against certain designs of apparatus or against apparatus manufactured by certain companies. This practice, of course, should not be countenanced unless the particular design discriminated against is one which is not considered a recognized standard.

"Some specifications cover methods of testing which are not con-idered accepted standards and which, therefore, involve the manu-acturer in unnecessary expense in preparing for witness tests.

"The principal defect of the present Government specifications is that they do not, in the majority of cases, permit the use of standard apparatus which has proven satisfactory to the general trade. t is inconceivable that the requirements of the Government should e such that it is necessary for manufacturers to build a special line f motors for its use. We do not believe that any such necessity really exists, excepting for apparatus to be used in the equipment f war vessels. In this paper, we are not referring to this class of apparatus, but simply to that which is used by the Government for

land service in applications similar in all respects to that of ordinary users.

"The types, classifications, and nomenclature of the present specifications differ from those of the American Institute of Electrical Engineers and American Association of Electric Motor Manufacturers, which we now consider recognized standards.

"The most elaborate witness tests are specified to be made at the expense of the manufacturer. We see no reasonable excuse for the Government requiring more elaborate tests than are required by other users, nor can we see any necessity for witness tests being specified for all motors.

"We see no reason for the Government specifications not being of such a character that they may be used by the small consumer and public in general, as guides in the purchase of motors without the fear that unnecessary special features will be involved, which will interfere with prompt deliveries and increase the cost over that of standard apparatus.

"The frequency with which Government specifications are issued is one of the greatest objections to them. The present specifications have been in force less than a year when completely new ones are proposed. Since January, 1902, four sets of specifications have appeared, making an average of one in about every twenty-two months. If these specifications are made up properly, they should hold for a much longer period unchanged, and, with slight changes and additions to keep pace with the development of the apparatus covered by them, they should remain in force indefinitely. It is practically impossible for a motor manufacturer to change designs of motors as rapidly as the Government specifications have been changed without serious losses from apparatus rendered obsolete, and it is therefore very desirable that the new specifications be made to agree with the most modern practice and that changes in them thereafter, excepting for a good cause, be discouraged."

As indicated, the paper from which the foregoing extracts are taken was presented before the American Association of Electric Motor Manufacturers, an association which is accomplishing some highly satisfactory results. Its methods may be taken as a good example of the right way to do things. The manufacturers have gotten together with a view of standardizing their products. By invitation of the Bureau of Construction and Repair of the Navy Department, a conference was held in Washington on May 28 and 29, 1909, at which were represented six bureaus and nine motor manufacturers, a total of twenty-eight men. Preliminary specifications had been issued by the Government engineers; these were freely discussed, paragraph by paragraph. A final specification has since been issued, substantially agreed upon, and practically

conforming to the rules and recommendations of the American Association of Electric Motor Manufacturers. These specifications apply to all departments of the navy yards and stations and are suitable either for the Government or the public. They were issued after Mr. Feicht presented his paper; hence his criticisms were directed at the earliest specifications and not those now in force.

After the conference, Electrical Expert Aide M. W. Buchanan, of the Bureau of Construction and Repair of the Navy, made the following statement with regard to the way in which the work had been done:

> "The valuable discussions on points where opinions diverged and the interest maintained throughout a rather long and tiresome conference, also the cheerful spirit which obtained under trying conditions, were all the subject of very favorable comment by the officers of the Bureau."

THE BUREAU OF STANDARDS

Obviously, it should be unnecessary for each of half a dozen or more bureaus and departments to prepare its own specifications for the same thing. There should either be a conference between departments, or some one department should prepare the specifications. While this could not be carried beyond certain limits, there is a very large list of ordinary standard productions, the specifications for which could be satisfactorily prepared in this way. This method has been carried out by the Bureau of Standards with respect to incandescent lamp specifications and electrical measuring instruments, and specifications are now being prepared for transformers after consultation with representatives of the Governmental departments and several manufacturers. This is certainly a logical and sensible method and is capable of great benefits to the Government,

Standard Government specifications, prepared in conference with the manufacturers, including tests which will determine the practical utility of the apparatus, and acceptable both to the Government and to the manufacturers, will not only benefit both parties, but will be accepted by the public. Therefore the Government, instead of being a disturbing element in industrial manufacture, may become a useful instrument in establishing standard commercial specifications which will be a great aid in standardizing American products. Both the general public and the manufac-

turers would welcome such specifications, assigning to them the weight which should properly be attached to the engineering work of the Government.

There has been very substantial progress away from the conditions which are exemplified in some of the instances of unsatisfactory specifications and tests which have been cited. There is a change from the old-time attitude, in which the Government in an ill-advised or arbitrary way, gave little consideration to commercial standards and methods, and, on the other hand, in which commercial interests looked upon the Government as a legitimate field for the sale of poor apparatus at high prices. There is a growing disposition within the Government bureaus to work together in engineering matters along the lines which modern business development has shown to be the most efficient. There is every reason why harmony and coöperation between departments and between the Government and commercial interests should lead to mutual advantage. The Government should foster the best industrial methods and practices. The engineering and commercial interests of the country should take a pride in Government work—the Government is theirs and they should, with a broad patriotic spirit, take pride in the excellence and economy with which its engineering functions are performed.

DISCUSSION

Lieut. Col. HARRY TAYLOR

Corps of Engineers

The paper prepared by Mr. Charles F. Scott, and read before the officers of the Engineer School at Washington Barracks, presents the manufacturer's point of view on Government specifications, but there is little in it that one can take exception to.

The ideal specifications are unquestionably specifications which would be uniform for all branches of the Government service, and which would enable any purchasing officer to obtain at reasonable prices things best suited to his purpose. Unfortunately, our Government is so constituted that it is hardly practicable to get the representatives of all branches of the Government together to agree upon specifications for any particular item. Another thing is that the requirements for the different branches—the Navy, the Army, and other branches of the service—for most items are not identical. This, perhaps, does not appear to be so to the ordinary manufacturer, but nevertheless it is, I believe, a fact beyond question. Of course, there are many minor items for which specifications could be prepared that should be suitable for all branches of the service, but for the main purchases of the different branches,

I believe that the statement that the requirements for the several branches are different, is correct.

It is also unquestionably true that the requirements for the Government service in many cases are different from the ordinary commercial requirements. For instance, the gasoline engine, of which I have been purchasing quite a number in the past, may be mentioned as an example. Every manufacturer to whom I have ever talked lays great stress on the fuel efficiency of his engine. Fuel efficiency is unquestionably a desirable feature of an engine. For commercial use it is probably the greatest, or, if not the greatest, very nearly so. For such use as the engines to which I have been purchasing are to be put, however, it is one of the very least important. For the purpose for which I have been purchasing gasoline engines, it is a matter of no practicable importance whether the fuel consumption is one pint per horsepower-hour, or one quart per horsepcwer-hour. This is something which it is very hard for the ordinary manufacturer to realize. Of course, if two engines were equally desirable in every other feature, the one having the lowest fuel consumption would certainly be preferable for the Government service over the other.

In drawing specifications "common sense" must be liberally used. No man with common sense would design a mechanical structure with a special I-beam of certain dimensions which would have to be specially rolled where a standard size of I-beam could be used. The standard sizes of I-beams is something that is well known, or should be known to every engineer, but there are things that have to be bought for the Government service occasionally which may be standard with manufacturers but which are not so well known to the purchaser. Every effort, however, should be made to ascertain what is standard, and, if practicable, to adapt that to the conditions to be met. Any man who would evolve a set of specifications from his own inner consciousness without making every effort practicable to ascertain what was standard in the line of the article he was purchasing, and whether or not such a standard article could be found, or what could be made for him at a reasonable price that would meet his requirements, would be lacking in the very much abused term "common sense."

When specifications are written, however, and a contract is made with a manufacturer to furnish a certain article based upon these specifications, it is very rarely that a departure from these specifications—no matter how small—is justified. The ordinary business man is in an entirely different position from the officer who is purchasing articles for the Government. The ordinary business man can, as Mr. Scott says, safely accept anything which approximates within certain reasonable range to his specifications, particularly if the essential and useful elements are satisfactory and the apparatus accomplishes its purpose. In the first place, he can limit his competition to those manufacturers whom he knows have an established reputation, and who will probably give him apparatus which will reasonably meet his requirements. It is imprac-

ticable for the Government officer to do this. When he issues a specification he is forced to give this specification to everyone who asks for it, and to allow everyone to bid, no matter what his opinion of the bidder is, and it is rarely indeed that he can accept any bid other than the lowest bid offered. He may be well satisfied that the low bidder is unreliable and that he can not furnish what is specified, but it is a case of a man being innocent until he is proven guilty, and the proof required has to be of a more definite character than he is perhaps able to furnish, although it would be sufficient to justify a business man in absolutely throwing out of consideration the lowest bidder. If he could limit his competition, as the business man can, he would be in an entirely different position to start with.

If a business man accepts an article, whether it meets the specifications or not, there is no one to criticize him, and his motive can not be attacked. If a Government officer or an inspector accepts an article which is not strictly in accordance with the specifications, he is liable to accusations of unfairness, and if his action becomes known he is almost certain to be criticised by other bidders who have failed to get the contract, and trouble is more than likely to ensue. No matter how unimportant the variation was, it gives the other bidders an opportunity to say "If I had known that the specifications were not to be literally complied with, I could have made a lower bid." This is a statement that is hard to disprove, no matter what the ground for it may be. It is only in exceptional circumstances that a piece of apparatus which does not meet the specifications in every way should be accepted by a Government agent, and then only with the knowledge and consent of the head of the department under whom the purchase was made.

In such exceptional cases as referred to by Mr. Scott, it would seem as if, upon the presentation of the case to the head of the department or bureau, authority for the modification of the specifications could have been obtained without undue delay and without subjecting the manufacturer to any penalty, if the matter had been properly handled.

It is a dangerous doctrine to teach the young officer that apparatus which varies from the specifications may be accepted. He should be taught that the proper thing is to make his specifications reasonable and correct when they are written, and that when a contract is made the specifications are binding upon both the contracting officer and the contractor equally, and that variation from them should be permitted only with proper authority.

Mr. J. W. Kellogg

Manager Marine Sales Department
General Electric Company

It seems to me that Mr. Scott loses sight of the real trouble with the Government specifications and why they are essentially out of the class of manufacturing for general sale commercially. Ninety

per cent of all the apparatus manufactured for sale commercially is subject to no acceptance test, except in the satisfactory use by the customer.

Under the system of competitive bidding established in practically all of the United States Government departments, it is necessary to test apparatus strictly in accordance with specifications, and it is generally expensive to carry on these tests for the benefit of whatever inspector may be detailed to pass upon the question of whether the apparatus meets the requirements of the specifications or not. The fact that these tests are required and that they must be sufficient to really determine the fulfilling of the specifications, makes the furnishing of apparatus for the Government in a special class.

The whole system of purchasing throughout the commercial world, is based on the responsibility of individuals who have authority to take the necessary steps to get the results, whereas, in the purchase by the Government there is very little authority for the individual.

I believe that much could be done in improving conditions under which apparatus is purchased by the Government, but it seems essential that the present system of competitive bidding on definite specifications, with assurance by complete tests that the specifications have been met, must be adhered to, so that it will hardly be possible to so standardize the specifications as to allow of purchases on a commercial basis.

In spite of all the special requirements of specifications, I think it can be generally stated that the Government purchases at a lower price than is paid by any other purchaser.

Mr. M. W. Buchanan

Expert Electrical Aid, Bureau of Construction and Repair
Navy Department

1. Primarily, specifications for electrical, as well as other material purchased by the Government, are essential, since they form the basis of the contract which the Government requires to be executed in the case of all transactions involving the expenditure of public money.

2. Specifications being, then, required by law, they should be so constructed as best to serve their purpose to the Government—that is, protect the Government from unscrupulous contractors, and at the same time enable contracts to be awarded, after full and intelligent competiton, and without delay, to the bidder who proposes to fulfill the intent of the Government's requirements at the most advantageous terms, and later, to enable the Government to determine with the least possible delay and expense to itself and the contractors whether or not the contract has been fulfilled.

3. Specifications which inherently accomplish this result may be considered ideal. As pointed out by Mr. Scott, Government speci-

fications for electrical apparatus often fall short of the ideal. The reasons for this may be summed up as follows:

a. The author of the specifications is not sufficiently well informed, with regard to the apparatus under consideration, to express clearly the intent of the requirements. In this event the bidders are depended upon to volunteer the necessary engineering information to enable the proposition to be considered. This often results in an unintentional injustice to certain of the bidders, and engenders prejudice.

b. The specifications are over-zealously drawn, and excessive requirements on unimportant details, with evidence of too much individuality on the part of the author, confuse the bidder, render the intent of the specifications less evident, and exclude useful competition by encroaching upon the field of the designer.

c. The bidder's familiarity with the Government's requirements is assumed by the author of specifications for material previously purchased many times, and the specifications are allowed to become too brief, admitting inferior material from an unexpected source.

d. A certain class of material which, in the work of the manufacturer, is produced under the same shop order and plans, may be proposed for practically the same purpose under two or more different Government departments, and, while accepted by one department may be rejected by another. Such a condition is the outgrowth of the independent development of different departments using similar apparatus, each department preparing its own specifications. Such specifications consequently bear the mark of the individuality of the author and are influenced by the particular requirements of the type of apparatus of which that department is the greatest user.

4. Obviously, the specifications rather than the apparatus are at fault in this case, and such specifications are very liable to merit classification under one of the three paragraphs (*a*, *b*, *c*) above mentioned, depending upon whether the department is a relatively large or small user of the material in question.

5. In defence of the Government engineer, it is fair to state that most of the faults in specifications are attributable to the causes in paragraph *b* above, and while over-zealousness has at times resulted in the expenditure of Government money from which no adequate return has been realized, it has encouraged the development of some new and desirable types of apparatus, which the manufacturers have been pleased to exhibit and advertise as "conforming to Government specifications."

6. Good business management would demand that the requirements for the same class of material for different Government departments be correlated under the authority of a proper executive head. This brings us to the question of "Standard Specifications."

7. Specifications naturally fall into two general classes, covering (I) material which is widely known and used and is in an advanced

state of development; and (II) material which is experimental, or the application of which is restricted to special cases.

8. To the first class belongs such material as Mr. Scott has mentioned to illustrate the multiplicity of Government specifications—that is, lamps, wire, and motors, also transformers, instruments, etc., for which the market is broad and the state of the art firmly established.

9. Here, then, is the field for "standard specifications," as exexemplified in the specifications for incandescent lamps, and the Navy Department specifications for direct and alternating current motors, the latter of which were prepared by the direction of the Secretary of the Navy for the use of all departments of the Navy on shore.

10. When properly drawn, the advantage of such specifications are manifold:

a. They protect the Government against paying unnecessary development charges on special apparatus, and they protect the manufacturer by allowing him to make advantageous propositions on his standard product with security.

b. They provide for uniformity of apparatus and facilitate the preparation of requisitions, making it unnecessary to prepare specifications for each purchase.

c. They are more permanent than individual specifications, and will require revision less often.

d. They prescribe the minimum of inspection which will insure compliance and set forth more clearly the responsibility of the inspector, thus making unnecessary the demand for his "pound of flesh."

e. They promote a more congenial relation between the manufacturer and inspector, by relieving the latter of that "gun shy" feeling, which is a common symptom among those who are called upon to scrutinize a piece of apparatus in accordance with the requirements of a subtle and intricate specification, and must needs keep their "skirts clear" on every count in the event of a future investigation of the test by a superior officer, who may or may not have had a hand in the preparation of the specifications.

f. They reduce to a minimum the element of uncertainty which contractors are accustomed to associate with Government business, and which is usually guarded against by a slight increase in the bid to cover "surprises."

11. But the principal advantage to the Government of standard specifications is the economy of buying in the open market, on the same basis with other large consumers. All the apparatus to which "Standard Specifications" may be applied has been developed along the broad highway of progress by the efforts of competent engineers, who have devoted their entire attention to the production of their specialty with a minimum of labor and material. Such a product is standardized and "manufactured" (as distinguished

from "built"). Obviously, when the purchaser departs from the broad market thus established for a given commodity, he immediately sacrifices the economy offered thereby.

12. Individual opinions may differ as to the advisability of requiring for Government purposes special features not included in standard commercial apparatus, at special prices. Standard specifications "iron out" all this individuality and reduce the purchase of a certain class of apparatus to the most practical basis. This feature may be illustrated by the problem of operating a horse-car system—samples of which may be found in New York City, Santa Rosa, Cal., and doubtless other places with which the writer is not familiar. The individual opinions of certain of the drivers and passengers, prompted by humane or artistic motives, might call for horses of not to exceed a certain age and capable of showing a speed, detached from the car, which would necessitate the horse having close relations in and about the celebrated "blue grass region" of Kentucky; but, the governing conditions of revenue and operating expenses, makes it necessary for the management to turn a deaf ear to the aforesaid opinions, and buy large quantities of animals which possess the requisite amount of stability, in a market which is broad and dependable and which will yield renewals in any quantity without disturbing the market price.

13. So with industrial motors for operating the general classes of machinery. A broad market has been established for this class of motors, and greater economy of operation will result from the purchase of good commercial motors and the renewal of the same from this market as required, than could possibly be obtained from the purchase of special motors with special operating characteristics and details of construction.

14. A point that is often lost sight of is the question of "reliability." This quality is bound to be possessed by apparatus which is successfully marketed in large quantities. It is very liable to be lacking in special apparatus. It is regrettable that this quality can not be given definite valuation and recognition in specifications, for as insurance of continuity of service, especially in cases where the product of the machine is relatively many times more valuable than the motor operating it, it ranks far beyond efficiency and other characteristics which are usually given great prominence in specifications.

15. Obviously, great elasticity is necessary in standard specifications to enable the market conditions to be taken advantage of to the fullest extent. The usefulness of the American Institute of Electrical Engineers standardization rules in this respect has been favorably commented upon by Mr. Scott.

16. The application of this quality is aptly illustrated in the steering gear of an automobile. Almost everyone has at times noticed the apparently loose and aimless way in which the front wheels of an automobile wobble about when travelling along an uneven road at slow speed. This would at first appear a poor mechan-

ical job, but experience has taught that in order to remove the strain from the driver's hands and the steering gear parts, this amount of elasticity and freedom is necessary. The thousands of cars in daily operation with this apparently loose-jointed steering arrangement is proof of its efficacy.

17. I quote the following from Mr. Scott's paper: "Obviously, it is impossible for the Government to use standard specifications if there are no standards." As set forth at the beginning of these comments, the Government has required specifications of some sort or other for every purchase of electrical apparatus which has been made. The Government early recognized the value of the application of electricity and has been a heavy purchaser of electrical apparatus from the first. The development of the art was rapid and, consequently, the specifications issued by the various departments required frequent revision to keep pace with the development. The number of necessary revisions multiplied by the number of departments issuing specifications make "an average of one in about every twenty-two months" appear quite reasonable.

18. While certain classes of electrical apparatus have been developed for several years to the point where standardization among manufacturers was possible, it was not until 1908 that the motor manufacturers organized and adopted definite standards. The Government's standard specifications for lamps were issued prior to that date, and the Navy Department's standard motor specifications a year later. (The Navy Department has for years issued standard specifications covering various classes of materials for naval purposes. These are revised from time to time as required, and they have done much toward establishing desirable standards and preventing undesirable specialization. There are upwards of 700 of these Navy standard specifications in force at present.) While the adoption of standard specifications for other classes of electrical apparatus might have been undertaken somewhat earlier, the present activity in that direction is not long delayed, and bids fair to keep conservatively in touch with the development of the apparatus itself.

19. The material designated above as Class II, which is experimental, or the application of which is restricted to special cases, must necessarily still be covered by specifications which can not be called "standard." Under this class comes electrical apparatus for use on naval vessels. The extreme importance of military preparedness and the special atmospheric and temperature conditions surrounding this apparatus, together with the rugged character of the same necessary to withstand the abuse of the service, places this material in a class by itself. Some of this apparatus could be well supplied from the commercial market, but it is difficult to segregate it.

As shown by Mr. Scott's "example of the non-conformity of specifications and lack of coöperation" in apparatus installed in the same compartment, it is evident that the work of standardization

of motor specifications for navy yard use, directed by the Secretary of the Navy, can well be extended toward the unification of the requirements of apparatus for naval vessels.

20. The only method by which specifications for standard apparatus can be made sufficiently comprehensive to fulfill their purpose in accordance with the foregoing, is by full and free coöperation among the departments which will use these specifications, and the same degree of coöperation between the Government representatives and the manufacturers. The result will be in the nature of a liberal compromise of unimportant features and the adjustment of the more important features to meet the demands of good engineering and the manufacturing requirements involved. The pressure of the specifications should only be felt in the vicinity of obviously inferior apparatus. The same methods should obtain to as great a degree as possible in the preparation of specifications which can not be made standard. The value of coöperation with the manufacturers can not be over-estimated, and both the Government and the manufacturers are to be congratulated upon the cheerful and friendly spirit which has prevailed at recent conferences between their representatives with regard to the requirements for Government apparatus.

Dam No. 10, Monongahela River, Damaged by Burning Oil*

An oil pipe burst at the pump station of the Eureka Pipe Line Company, located just above Lock No. 10, and considerable oil leaked into the river when the water in Pool 10 was drawn below the crest of the dam. At about 2 p. m. on October 29th, when the wind had collected the oil in the corner above the abutment end of the dam and the waves had deposited a quantity of the thickened oil on the top of the dam, some one set the oil on fire. The heat from the burning oil was so intense as to completely destroy the mortar finish on top of the dam, which was about 2½ inches thick, for a distance of 50 feet by breaking the bond between the mortar and the concrete, and the mortar into small pieces. The mortar cracked with such force as to produce loud reports and to throw chips to a distance of about 75 feet.

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* Report by United States Assistant Engineer J. L. Callard.

COMPARATIVE TESTS OF WYE AND DUMPY LEVELS

BY

Lieut. JAMES G. STEESE
Corps of Engineers

The question having arisen at the Engineer Depot, United States Army, as to the advisability of changing the type of engineer's level used by engineer troops in the field and on construction work in the Engineer Department at Large, comparative test-runs were made in September and October, 1910, of levels of the Dumpy and Wye types. By the use of the dumpy level more generally, satisfactory service was expected and, in addition, there would be a saving of about 20 per cent in first cost of instruments.

For the test runs a Buff and Buff wye level No. 7196, 18-inch telescope, cost $126.00, and a Buff and Buff dumpy level No. 7072, 18-inch telescope, cost $91.00, were used, both instruments being new.

The runs were made at various times during a period of about a month, in a bright sun and heavy wind, and also on cloudy, damp days. The instruments were carefully adjusted the first day, and no further adjustments were made.

The table below shows in detail the results obtained. In figuring the allowable error of closure of each circuit, I have used the formula

$$E=0.02\sqrt{D}$$

where E=allowable error in feet
and D=length of circuit in miles.

This formula is the usual standard for precise levels in the United States Engineer Department with a *precise levelling* instrument. We have used the same formula for our check levels on the Panama Railroad Relocation, using an ordinary engineer's wye level.

The "A" runs were made at the depot, upon comparatively level ground. Maximum sights of 250 feet were taken; all back and fore sights were balanced by pacing. Self-reading rods were used and the thousandths were estimated by the instrument man. On this part of the work I was assisted by Lieutenants North and

Lyman, Corps of Engineers, each of whom ran two circuits with each instrument.

The "B" runs were made in the field, near Congress Heights, D. C., on rough ground covered with brush, approximating working conditions. The sights varied from 50 to 300 feet, and were practically balanced; the rod was read to hundredths.

All runs were closed on the starting point.

Kind.	Run.	Dumpy Level.			Wye Level.		
		D miles.	Allowable error.	Field error.	Field error.	Allowable error.	D miles.
A	1	1.56	0.025	−0.041	−0.022	0.025	1.48
	2	1.53	0.025	+0.021	−0.024	0.025	1.50
	3	1.35	0.023	−0.005	−0.006	0.024	1.40
	4	1.40	0.024	—0.038	—0.014	0.025	1.49
	5	0.72	0.017	−0.012	—0.016	0.017	0.72
B	6	2.89	0.034	+0.03	+0.02	0.038	3.68

There is no difference in speed between the two instruments. The dumpy level is more compact, lighter, and simpler to work with. From its solid and substantial construction, it would seem almost impossible to injure it by any ordinary blow or fall. Abuse or a bad accident would, of course, render either instrument valueless. To check the adjustment of the dumpy level by the peg method requires more time than to adjust the wye level, but the adjustments once made would be retained under rougher handling. and for a longer time.

To develop the relative accuracy under continued use would require more extended tests, but the above results show the dumpy level to be capable of greater accuracy than is ordinarily *required*, and it is believed that the dumpy level is the safer instrument to use on miscellaneous work, especially on construction; the Wye level being reserved for establishing long bench lines.

REPLACING LOCK GATES ON THE KANAWHA RIVER

BY

MR. THOMAS E. JEFFRIES
Assistant Engineer

The following description of the method used in replacing the lock gates on the Kanawha River is given in order that it may be compared with that employed on the Galena River, as described by Assistant Engineer S. Edwards, in the PROFESSIONAL MEMOIRS for October-December, 1910.

Mr. Edwards' description is interesting and instructive for situations where gates of light material and design are used, but would not suit conditions as found on the Kanawha River. The illustrations show how the upper gates could be handled with the lower gates closed and the pool full, but do not fully illustrate how the work was done in the lower pool, unless the water was held up with a cofferdam. If these gates were light enough to float, could they not have been floated into the gate recesses and raised into position with crabs? Why should a cofferdam have ever been thought of?

The Kanawha River has fluctuations of 45 feet and more, in consequence of which the gates have to be built on the bank above ordinary high water. They are built of oak, which, with the addition of the valve frames, valves, and other irons, makes them much too heavy to float; the weight of a single gate, ready to be placed, being thirty tons or more, according to the location.

The method pursued here is as follows: Two gates are built on the top of the bank, generally below the lower entrance to the lock. When these two gates are finished, they are lowered on skidways down the bank and out into the river far enough for an empty flat-bottom boat to be floated over them. Heavy timbers are placed across the deck of this boat with their ends projecting beyond the gunwales; the width of the boat used being less than the height of the gates. The gates are then pulled up close to the bottom of the boat and held there with chains fastened to the projecting timbers. You are now ready for work in the lock chamber, but have not in-

terfered with navigation. At locks where the gate bays have not been filled, a stick of timber is placed diagonally across the upper end of the gate recess under the end of the gate, one end resting on the cross- sill and the other on an offset in the masonry. The old gates are unfastened at their anchorage, lifted, and pulled a short distance upstream to release them from the quoins and pintles, after which they are lowered into the lock chamber with crabs located on the lock wall. A second boat is floated over the gate,

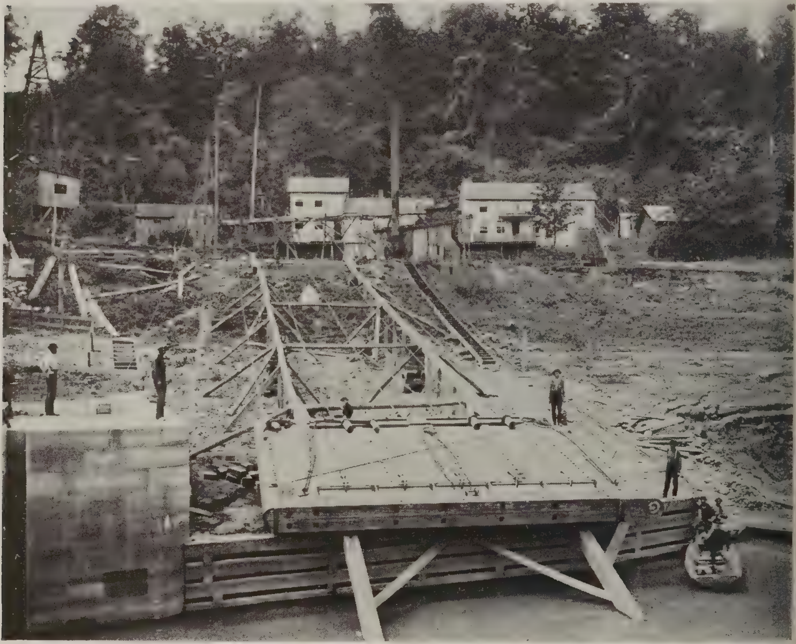


Fig. 1. Launching one of the Lock Gates, where it was built and moved, into the river at the lower end of the lock. The chains attached to eye-bolts are for holding gate to bottom of boat. Block in lower left hand corner acts as a cushion to prevent gate striking the back of the recess and breaking valves or rods.

and it is picked up and fastened to the bottom of the boat in the same manner as the new gates. The boat with the new gate is floated into the chamber and laid close to the wall with the timbers of one side projecting into the gate recess, which also allows the bottom of the gate to lie partly in the recess. The gate is then unfastened and lowered, allowing the boat to be floated away. The gate is then raised to a vertical position with lines and blocks by

means of the crabs fastened to timbers on lock wall, as will be seen in the illustration (Fig. 2). It is then raised with jacks and pushed back into position and dropped onto the pintle.

In jacking up both the old and new gates they are suspended by chains crossing the jacks on wooden saddles, the jacks being placed on a timber running the full length of the gate recess, directly over the gate, the timber being held in position by a cross-timber fastened to the lock wall, or weighted down with old irons or tone. By placing the chains so that they will lead, the gate is asily shifted back into the quoin and over the pintles

Fig. 2. Raising one of the Lock Gates. After being pulled up to a vertical position, the gate is lifted up by jackscrews applied at the top and is then lowered on pintle. The upper fastenings are then attached. The sheathing shown on bottom side of the gate is put on to protect gate and allow it to slide on skidways. It is removed when gate is hung.

The time required to take down two old gates and hang two new nes is between five and six days of eight hours, or from forty to orty-eight hours of continual labor. The fastest time that has een made in putting in a gate was to start from the top of the

bank and hang it in eight hours — this refers to a new gate, and not to a replacement.

In doing this work the same force is employed that builds the gates, composed mostly of carpenters, and while this class of labor apparently increases the cost, I think it is fully compensated for by the better class of trained labor employed. If the working time of the men employed could be increased to ten or twelve hours per day the suspension of navigation could be materially reduced.

Charles Gratiot

Charles Gratiot (see frontispiece) was born in Missouri in 1788, and entered the United States Military Academy from that State on July 17, 1804. He graduated October 13, 1806, and was appointed Second Lieutenant of the Corps of Engineers. He served on engineer duty in Missouri Territory from 1806 to 1808, when he was appointed Captain of the Corps of Engineers, February 23, 1808. He was assistant engineer in the construction of the defenses of Charleston Harbor, S. C., 1808-1810, and on duty at the Military Academy from 1810-1811.

In the War of 1812, he was Chief Engineer of the Northwestern Army, under the command of General Harrison, during the campaign of 1813-1814, being engaged in the defense of Fort Meigs, April 28-May 9, 1813, and in the attack on Fort Mackinac, August 4, 1814. He commanded the detachment which landed near the mouth of the Natewasaga on September 13, 1814, and destroyed six months provisions belonging to the enemy. He was appointed Brevet-Colonel, Michigan Militia, October, 1814, and Major, Corps of Engineers, February 9, 1815.

He was Superintending Engineer of the fortifications on the Delaware River and Bay, 1816-1817; Chief Engineer of Department No. 3 (Michigan and Northwest Territory), 1817-1818, and Superintending Engineer of the defenses of Hampton Roads, Va. 1819-1829. He was appointed Lieutenant-Colonel, Corps of Engineers, March 31, 1819, and Colonel and Chief Engineer of the Army, May 24, 1828, and on the same day was made Brevet Brigadier-General for meritorious services and general good conduct He was in command of the Corps of Engineers, in charge of the Engineer Bureau, and (ex-officio) Inspector of the Military Academy from May 24, 1828, until December 6, 1838, and during th

same time was a member of several ordnance and artillery boards. On December 6, 1838, he was summarily dismissed by President Van Buren for "having failed to pay into the Treasury the balance of the moneys placed in his hands, in 1835, for public purposes, after spending therefrom the amount which he claims to be due him on settlement of accounts, according to the President's order, communicated to him by the Secretary of War on the 28th Nov., 1838; and having neglected to render his accounts in obedience to the law of Jan. 31, 1823."

The Committee on the Judiciary made, August 31, 1852, to the Senate of the United States, the following report on the memorial of General Gratiot, which had been referred to it:

"* * * The career of the petitioner in the Army of the United States, during a long period of nearly forty years, is a matter of history that may justly excite the pride and admiration of every American citizen. Brave in battle, he presided, for a long time, with distinguished honor and ability, at the head of one of the most difficult and arduous bureaus of the military department, and has left to the country lasting monuments of his skill and science in the construction of various magnificent fortifications, both to exhibit her strength and to insure her safety.

"While thus honorably and usefully employed in the public service for so many years, he was constantly confided in by his country, and never abused her confidence in the disbursement of immense sums of money, and lived honored and respected by all classes of mn, with no taint of suspicion attaching to his name.

"With a character so high to sustain him,the charge of malfeasance should be received with great caution by the people, and rigidly scrutinized by Congress, and no unjust influences of any nature whatsoever, should be permitted to prevail in his case; but if, unfortunately, such influences do obtain ground, then it is obviously the imperative duty of Congress to remove them, for no higher duty devolves upon the federal legislature than the protection of the honor of its military officers, of which it is necessarily, to a very great extent, the chief custodian.

* * * * * * *

"In support of his first plea, the petitioner exhibits a mass of testimony, which is certainly entitled to be very calmly weighed and measured; and among the same is the opinion of the General Commanding-in-Chief, upon a parallel case, than which no authority can be higher.

"In support of the second plea, he denies totally the truth of the charge of defalcation, and contends that he is not, and never was, indebted to the United States for moneys misused by him, and that a just and legal adjustment of is accounts will bring the United States in debt to him; that the withholding f the funds, upon the demand of the Secretary of War, was a measure of self-efence, justified by the circumstances of the case, and that he was then and s now prepared for an equitable settlement, which is his demand and desire.

"It seems to the committee that both of the pleas are reasonable, and

should receive attention, urged as they are, with the earnestness of conscious rectitude, by a gallant soldier, who has acquired a right to be heard from the blood he has spilled in battle. * * * ''

From 1840 to 1855 he served as a clerk in the General Land Office, Washington, D. C., and died May 18, 1855, at St. Louis, Mo.

As testimonials of his services in the Northwest, Fort Gratiot, Mich.; Gratiot County, Mich., and the villages of Gratiot, Mich., and Gratiot, Wis., were named after him.

A COMPLETE FLOATING CONCRETE PLANT

BY

Lieut. L. M. ADAMS
Corps of Engineers

The type of concrete plant described in this sketch is substantially the same as one which was recently operated very successfully in connection with the hired-labor work at new Lock and Dam No. 5, Monongahela River, at Brownsville, Pa. Experience gained on that work has indicated several improvements, all of which are incorporated in the new design. A plant of this type necessarily has limitations to its proper field of use, the imperative requirement being a depth of water for flotation which will not fall below 4 feet; this depth is about the minimum for operating derrick-boats, sand and gravel flats, and other floating plant commonly used in the construction of large works of river and harbor improvement. The "mixer" is obviously designed with the idea of being supplied with sand and gravel from barges which are moored alongside during the operation of the plant, these materials being hoisted by clam-shell bucket into the storage bins located over the charging hoppers. The mixed concrete is usually removed by a derrick set up between the forms and the floating mixer, or else by a derrick-boat moored within reach of both forms and mixer. The cofferdam must be laid out with this object in view. The plant is designed to operate with a minimum of labor and fuel; and experience has shown that it will continuously supply over twenty 1½-yard batches of well-mixed concrete per hour for three shifts of eight hours each daily. The plant used on the Monongahela River never broke down during a year and a half of heavy duty. Such a satisfactory performance speaks well for the Ransome mixer installed.

The equipment will include a first-class stiff-leg derrick with 55-foot boom, three-drum hoist, and separate steam swinger mounted as far toward one end of the barge as space will permit. A duplicate set of upright boilers of 30-horsepower each will furnish steam for the operation of the entire plant, one fireman only being

required. In case of repairs to one boiler the other can be worked at overload temporarily. The coal bins are located at the extreme end of the barge to partially counteract the weight of the heavy cement storage shed and to be convenient to the fire doors. Coaling is ordinarily to be done from a coal flat with a second derrick, and requires only a few clam-shell bucketsful to fill the bins.

The importance of installing the best machinery throughout can not be overemphasized, and I would recommend a Lidgerwood or Mundy 8¼ by 10 inch tandem three-drum hoisting engine, with separate steam swinger. The clam-shell should be operated on a single line for speed, and the 8¼ by 10 inch engine is none too large. The patent swinging device geared to the main engine can never take the place of a separate steam swinging engine. The mast of the derrick should be mounted with a forward tilt. This arrangement greatly facilitates the swinger in bringing inboard a heavily loaded clam-shell which necessarily gives the barge an appreciable list when first hoisted from the flats alongside. The load and closing lines of the bucket should be rigged about as shown in the illustration, as this puts the least strain on mast and stiff legs. Experience proves that it pays to buy the best extra pliable plough-steel rope for rapid operation over small sheaves, and the eight-strand type of nineteen wires each is the best.

The sand and gravel storage bins are so built as to allow the clam-shell operator to see into them from his post at the lever stand, and he is thereby enabled to dump his load without mixing or waste The bins have a combined storage capacity of about 60 cubic yards (gravel, 40, and sand, 20), sufficient to allow the mixer to continue operating for over an hour in case of minor repairs to the hoist or derrick. The bins are designed so that all their contents will flow by gravity to the charging hoppers just below. The gravel hopper is filled by throwing a lever, which opens a horizontal door below the gravel bin; when full,this bin holds exactly the proper charge of gravel for one 1½-yard batch of concrete. Similarly, a second lever fills the sand hopper with the proper charge of sand. No time is thus lost in any rough attempts at measuring, and the scheme insures uniform mixtures. Water is admitted to the mixe proper in the usual manner, but the drip from the sand and grave bins above makes the quantity of water to be added to each batch quite small.

The following capacities of sand and gravel hoppers are abou correct for 1½-yard batches of 1 : 3 : 6 concrete:

Capacity of gravel hopper, 35 cubic feet; capacity of sand hopper 17 cubic feet; six sacks of cement, 95 pounds each.

Care must be exercised to see that the gravel used does not contain an excess of sand when delivered, as such excess does not increase the volume of gravel and necessitates a reduction of the capacity of the sand hopper. This may be conveniently done by nailing a wooden block of the proper volume within the hopper and removing it when gravel, free from sand, is furnished.

The sand and gravel for Lock No. 5, Monongahela River, was purchased under specifications calling for a price per bushel, and defining a bushel as 1.27 cubic feet. These specifications proved most satisfactory to the Government, but less so to the sand and gravel contractors, because the excess of sand in the gravel was often considerable and only evident from the increased displacement of the flats. The actual cubic contents of each flat was obtained in cubic feet, and this quantity divided by 1.27 was the basis of payment. The result was that the contractor furnished about a third of the sand used on the work without receiving payment therefor.

Cement is supplied to the charging hopper by means of a small car running on double tracks, which form an incline from the cement shed to the hopper. The shed shown has a capacity of 1,000 barrels, which is sufficient for the average run. While setting up new forms, the mixer is moved to the proper point and the shed is loaded with cement in bags. Where local conditions permit, a most satisfactory method of loading cement consists in a wooden chute built down a steep bank with a railroad siding at the top of the chute. The cars are side-tracked at the chute and the bags are thrown into it, descending by gravity into the shed on the mixer. This arrangement supposes the cement to have been tested at the manufacturer's and already accepted when it arrives. The small cement car is open at the top and front and is large enough to hold the contents of six bags of cement. It is hauled to the top of the incline by a cord passing around two pulleys near the mouth of the charging hopper and attached to a drum driven by a small reversible steam engine. When the car reaches the top of the incline the front wheels drop between the outer rails, up-ending the car, the small hoisting engine is automatically stopped and reversed, lowering the empty car down the incline to be reloaded.

It is imperative to keep the cement shed and bins as low down as possible for favorable effect on the center of gravity of the whole

barge; for this reason the deck is built in two levels, the higher one serving to raise the main hoisting engine so that the clam-shell operator gets a clear view over the gunwales and into the inclined tops of the sand and gravel bins.

Below the spout of the mixer is a concrete hopper with sufficient capacity to hold 1½ cubic yards of concrete. The object of this hopper is to receive a mixed batch and allow the mixer to continue operatng and avoid the delay of waiting for the concrete bucket to receive each batch direct. Such an arrangement also allows the use of a 3-yard bucket. Placed beneath the concrete hopper, such a bucket receives the 1½-yard batch already in the hopper, and as the door of the hopper opens, the mixer spout is also lowered, allowing both batches to run into the double-batch bucket simultaneously.

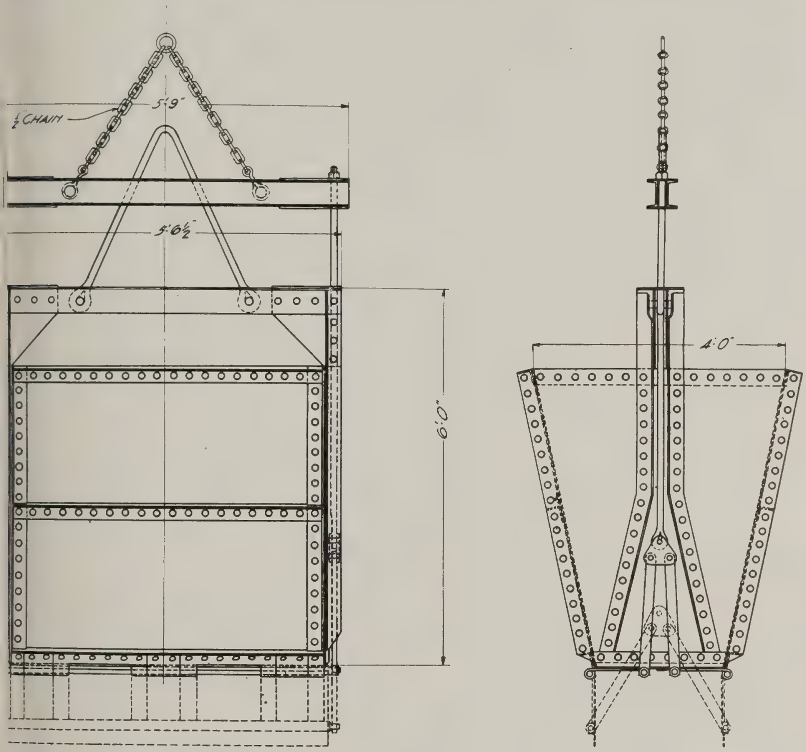
It would be possible to design this plant with a view to using a ''continuous mixer'' of the Foote type. Such a mixer would not require the measuring of the sand and gravel in charging hoppers, and would permit the heavy sand and gravel bins to be lowered and enlarged if considered desirable. Most of the concrete specifications issued by the Department at present call for the concrete to be mixed in a machine of the ''batch type,'' which, to be consistent, would bar the installation of a ''continuous mixer.''

It is not practicable to mount a second derrick on the mixer barge to deliver the concrete to the forms, because the listing of the barge from the clam-shell loader would make it very difficult to handle the concrete bucket at the forms. If the bags of cement are to be delivered from a cableway, it would be desirable to have part of the shed roof removable so that the skip could be lowered directly into the shed.

To increase the usefulness of such a plant, a standard Westinghouse railway air-compressing outfit can be installed near the housing for the boilers. The compressed air will be of use in operating pneumatic boring machines, which are a great convenience on heavy timber work.

The most satisfactory concrete bucket ever used on the Monongahela River work is shown in the cut. Its most marked advantages are that it is narrow enough to be used with almost any kind of heavy concrete forming. It can be partially dumped at one end of the form, then moved to the other end and emptied. It does not ''kick'' or recoil in the least, thereby saving much damage to forms and preventing accidents to the laborers in the forms. It is very

strong and durable and never fails to open or close instantly, on signal to the engineman. Its only disadvantage is that it requires two lines for operation, one for opening and closing, and a load line. Any first-class machine shop will make one for $175, or less.



BOTTOM DUMP CONCRETE BUCKET
USED AT
NEW LOCK & DAM NO. 5 MONONGAHELA RIVER.
CAP'Y - 2 CU. YDS.

The following men would be necessary to operate the whole concrete mixing plant.

One clam-shell operator, at $3.00 per day; 1 mixer-engine man, at $3.00 per day; 1 fireman, at $2.40 per day; 1 skilled laborer at harging hoppers, at $2.40 per day; 1 laborer in cement shed, at $1.80 per day; 2 laborers under concrete hopper, at $1.80 per day each. Total labor, $16.20 per day.

The amount of soft coal needed for firing boilers to furnish an

average of 40 horsepower, would be two-thirds of a ton for each shift of eight hours.

The first cost of such a plant would be approximately as follows:

Hull of barge	$4,000
Coal, sand, and gravel bins	600
Boiler house and cement shed	300
Derrick, complete, with three-drum hoist and two boilers	3,300
1½-yard clam-shell bucket	600
Mixer, complete	1,300
Cement car and hoist	400
Total	$10,500

[TRANSCRIPT]

THE FINAL STRUGGLE FOR 203-METER HILL AT PORT ARTHUR*

(Reprinted by permission of the Royal Engineers Journal)

(Continued from PROFESSIONAL MEMOIRS, No. 8.)

November 29.—Visokaya Hill was bombarded all night with every sort of shell, and although the firing was less intense than it had been during the day, yet the damage done exceeded the repairs which it was possible to carry out during the night, while the continual firing kept the garrisons of both hills in a state of extreme anxiety. Another demonstration was made in the direction of Pigeon Bay, but Captain Romanovski, with his detachment, did not allow it to advance far.

At 6.30 a. m. some Japanese infantry moved forward against the right flank of Visokaya, but were easily driven back, owing to the failure of their main attack against the left redoubt, which was dispersed by the quick-firing guns in the neighborhood of Pigeon Bay.

During this day these guns, under Staff-Captain Nezhentsov and Lieutenant Siromyatnikov, were especially successful. This was due to the fact that one of the sections had with it about 80 Chinese common shell, which, though intended for use with ordinary powder, were nevertheless suited to the Russian guns, and proved an unpleasant surprise to the Japanese, who had hitherto gained complete cover from shrapnel in their trenches and blindages.

Selecting the moment (6.30 a. m.) when the Japanese were massing for the attack, these officers opened a rapid and well-directed fire on the trenches. The Japanese, finding that their trenches no longer protected them, retired down hill and round to the north, and 40 shell were sufficient to disperse the column intended for the attack on the southwest slope of the hill.

At 7.30 a. m. an order was sent by telephone to Staff-Captain Marchenko, commanding the Eighth Company, Fifth Regiment, on False Hill, to detach a section to occupy a small unnamed knoll in rear of Visokaya, in order to prevent the enemy from gaining access to the Tea Ravine, between Flat and False hills, in the event of the fall of Visokaya Hill.

At the same time the Sixth Company, Fifteenth Regiment, under Lieutenant Silvin (120 men), and a company of about 91 sailors were sent to reinforce Visokaya. At 8 a. m. Staff-Captain Belozerov reported their arrival, and also that large reinforcements were arriving for the Japanese from beyond Angle Hill.

At 7 a. m. the Japanese increased their fire on Visokaya Hill with 11-inch and 6-inch shells and with mines, and maintained it until evening.

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*Translation of an article by Staff-Captain Kostiushko in the March, April, and May numbers of the Eenzhenernee Zhoornal.

At 3 p. m. Belozerov reported that only two of the blindages on the left flank remained uninjured, and that these were occupied by sailors. All the rest were wrecked, and it was hard to say how many men were buried in the débris, as communication along the trenches had been interrupted.

While the artillery fire was thus destroying the works and causing great losses among the men, the Japanese infantry were able to approach without molestation and mass secretly in their saps and approaches, and at 4 p. m. these masses moved forward to the assault.

With their trenches interrupted and their numbers terribly thinned, the Russian riflemen, reduced to a few disconnected handsful, were unable to resist the shock of the advancing masses, and all perished, while the Japanese penetrated to the very summit of the hill and there planted their flag. General Tretyakov had only 100 men in reserve when he was informed of the sudden appearance of the Japanese on the crest. On the left summit the enemy's flag was floating, and thither dashed Belozerov with a section hastily taken from this reserve.

This example of action encouraged all, and simplified matters for General Tretyakov, who forthwith sent another section in support, and himself led the rest against the saddle and the right redoubt. Lieutenant Seifulin, Fifth Regiment, who was also on the hill, took an active part in driving back this assault.

The following reinforcements were then sent to Visokaya Hill:

A composite company from the boat reserve (155 men, under Lieutenant Normand).

The company landed from the *Poltava* (109 men, under Lieutenant Baranov and Midshipman Yunkovski).

The company landed from the *Sevastopol* (87 men, under Midshipmen Petrov and Shnakenburg).

And to Flat Hill the following hospital detachments:

First: 150 men, under Lieutenant Suvorov, Twenty-fifth Regiment.
Second: 150 men, under Staff-Captain Maslenkov, Twenty-sixth Regiment.
Third: 90 men, under Lieutenant Vasilevski, Twenty-eighth Regiment, and 45 convalescents without an officer.

The Fourth Hospital Detachment arrived later.

Captain Geiking, commanding the Hospital Battalion, was also sent to Flat Hill.

During the skillful counter-attack on the left redoubt, Staff-Captain Belozerov was struck in the head by the splinter of an 11-inch shell and part of his brain was laid bare. He was borne from the hill in a state of unconsciousness, while his men, who had been encouraged by his example, completed their work. In spite of the numerical superiority of the enemy, they drove them at the point of the bayonet from the left redoubt, and captured their flag and sent it to the Fifth Regiment headquarters.

At 5 p. m., when the reinforcements came up, the rest of the hill was cleared of the enemy, a result due in part to the energetic action of General Tretyakov, in part to the gallant conduct of the men and officers, and in part to the skillful artillery practice from Forts Nos. 4 and 5, Entrenchments Nos. 4 and 5, Bat-

tery Letter D, Red Hill, and above all to that of the quick-firing guns in Liudzyatun village on the left flank.

The artillery commander on Red Hill, Staff-Captain Kornilovich, Fourth E. Siberian Rifled Artillery Brigade, did all he could to assist the infantry, carrying his enthusiasm for his quick-firing guns to the point of laying them himself. That the fire from Red Hill was specially annoying to the Japanese was evident from the fact that on it was directed the fire from several of their batteries. Kornilovich, deeply engrossed in his firing, paid no attention to the shells which were falling within a few paces of him, and continued his accurate fire in spite of the entreaties of his men to go under cover. In the end the gun which he was working was struck by a Japanese shell, and splinters from a broken wheel covered him with wounds, from which he died before reaching hospital. He was at once replaced by Captain Benua, already distinguished on the 16th of May, who successfully carried on the firing and was fortunate enough to escape uninjured.

About 4 p. m. Captain Nezhentsov and Lieutenant Siromyatnikov, observing to the front of Visokaya, noticed dense columns of Japanese reinforcements going up the hill, and opened on them a rapid mixed fire of shrapnel and common shell from their four guns. Again the Japanese could not endure this, and broke in disorder, leaving killed and wounded on the slope.

In this way the assault was repulsed by the mutually supported action of infantry and artillery.

At the same time the Japanese assaulted Flat Hill, and again they chiefly directed their efforts against the unfortunate section near the dead ground. On this occasion the section was occupied by part of the Ninth Company, Fifth Regiment, the remainder of the company holding the trenches farther to the right.

The Japanese infantry were within 50 paces, carrying on a hand-grenade and rifle fight with the Russians, while their artillery battered the trenches of the whole hill, and especially of this section, with 6-inch and 11-inch shells and mines. The losses were very great, and in the ''unfortunate'' section the men had to be taken out and only sentries left. Towards evening the attack took place, and before the sentries could report its approach the section was in the hands of the enemy. The company on the left also evacuated a part of their trench. Seeing this success, the Japanese, in number about a battalion, moved up to the Stony Redoubt and lay down on the glacis, leaving in the captured portion of the trench only a small party with the wounded. The Ninth Company, under Lieutenant Sirotko, without loss of time charged to the left along the trench and drove out the Japanese, reoccupying the whole of the captured portion of their trench.

At this time there came up two companies of Japanese reinforcements. The Ninth Company received them with grenades and rifle fire, and these companies, not expecting such a surprise, broke back to their trenches and opened fire. Part of the Ninth Company engaged them with rifle fire and grenades, and the rest of the men faced back up the hill and opened fire on the Japanese, who were lying on the glacis of the Stony Redoubt, at about 200 paces distance from their trench. This fire proved so effective that the Japanese were put into disorder, and small parties and single men began to fall back, but were shot down by the men of the Ninth Company. The rest were also harassed

with rifle fire and grenades from the redoubt, and at last they could stand it no longer and all broke back to the place where they had crossed the trench. Many volunteers from the Twelfth Company, Fifth Regiment, ran to the assistance of the Ninth Company, and all opened a heavy fire, from which many of the Japanese fell on the slope; but a few succeeded in reaching the trench and joined in a bayonet fight, from which about 20 of them eventually succeeded in rejoining their comrades. The losses of the Ninth Company amounted to more than 40 men, and the company was replaced by the Tenth Company, Fifth Regiment.

About 7 p. m. Captain Stempnevski I. arrived and resumed his duties as commandant.

After several more unsuccessful attacks on Visokaya and Flat hills the Japanese infantry drew off about midnight, but the artillery as before kept up their fire all night. The Russian losses on the 1st of December amounted to from 600 to 700 men.

The continual bombarding of Visokaya caused many casualties. If there had not been constant expectation of infantry attacks, it would have been possible to remove the men during the bombardment; but this could not be risked, and consequently great losses were incurred from artillery fire, the men being replaced from time to time from the reserves. In this way the reserves gradually melted away, and requests were constantly coming in for more men and also for grenades. At first whole companies, each of 100 men, were sent up, but even by the 29th of November there began to come up small parties of stretcher bearers, odd men, and convalescents, without rifles and ammunition; these men were very keen to join the fighting, but it was often a matter of question whether they were fit for it, and in fact whether they were of any use whatever.

In the parties from the hospitals were to be found men of various regiments, including sailors and gunners. Each of them had some physical defect; one was so lame that it took him half a day to march some 1½ to 2 versts, another could not use his hand, and a third had lost an eye. Others could hardly move from weakness, due to wounds, exhaustion, or incipient scurvy. The very sight of such fighting men made one shudder!

As the writer was then regimental adjutant, all these parties reported to him, and his feelings may be imagined when he had to place arms in the hands of such cripples, and form them into detachments, and send them up to the front. As a matter of fact, the greater part of them he sent to Entrenchment No. 4 and Fort No. 5, as in those works, if the Japanese should advance, three cripples might take the place of one uninjured man, if the latter were urgently required elsewhere. This gave a certain amount of excuse for taking the First Volunteer Party, Fifth Regiment, from Entrenchment No. 4 on the 30th of November.

General Stessel, at his wits' end for reserves, gave orders to replace the active service rank and file of the bearer companies by town guards, and to form from them the Hospital Infantry Battalion, under the command of Captain Baron Geikin, Eleventh Regiment. These men he sent to the Staff of the Western Front as a reserve, and was thus able to improvise 600 men at the expense of all the hands skilled in the care of the wounded.

The Japanese continued to pound Visokaya Hill all night with 6-inch high-

explosive shell, shrapnel, and mines, supplemented with 11-inch shell, which the soldiers called ''steam engines,'' and which fell at the rate of one every five or six minutes. The fire was less intense than it had been during the day, but it caused a great amount of damage and casualties. General Tretyakov strove to carry on work at repairing damage and restoring communication in trenches and approaches, personally superintending the work, and by exposing himself in the most dangerous places set an example of courage that urged the men to increased efforts. The name of Ensign Ermakov deserves mention as his chief assistant in this strenuous work.

But however hard they worked the night's bombardment destroyed more than they could repair. Some idea of the intensity of the fire may be gained from the fact that, during the 29th of November, of 11-inch shell alone there were counted more than 1,000, while of 6-inch shell and projectiles of smaller calibers all count was lost.

November 30.—During the night the Japanese again made a demonstration in the direction of Pigeon Bay, but without results. At 5.30 a. m. it was noticed that the enemy was cutting the wire entanglement on the southern slope of Visokaya Hill, and in other places where it had been repaired with so much trouble overnight.

The Japanese artillery fire increased in volume before 7 a. m., and on this day it attained the most enormous proportions. On the 30th they both shelled and assaulted the hill in the most determined manner, and neither before nor after did they make such exertions to capture it as on this day.

The weather was clear and sunny; in the still air the constant bursting of the shells completely hid the upper slopes of the hill in clouds of smoke and dust. The hills re-echoed with the explosions of shells, the crackling of machine guns, and the volleys and rapid fire of rifles. General Kondratenko arrived early at the Fifth Regiment headquarters, and through the field glasses followed the progress of the fight on Visokaya. Company after company of reinforcements, now almost exclusively composed of sailors, kept on coming up. The telephonists received so many messages from various points along the land front, reporting the fact that from all sides the Japanese were seen to be moving on Visokaya, that they had no time to write them down and despatch them.

At 8 a. m. a desperate attack took place, and the weak point was again the left redoubt. Its defenders were overwhelmed and the Japanese established their flag on it. General Irman, noticing this through his field glasses, sent orders by telephone to ''at once drive the Japanese from the left redoubt,'' and despatched at 8.35 a company of the Twenty-eighth Regiment, and at 8.45 a company of sailors.

Meanwhile, General Tretyakov had already sent the reserves which were with him in counter-attack against the left redoubt, and the Japanese were driven out. At other points the Russians held their own, yet the Japanese did not retreat, but kept on climbing and planting their flags at various points on the hill, were driven down again, and yet again clambered up with astonishing determination. It is difficult to say how many attacks were carried out at this time, in fact it was one uninterrupted attack from dawn to midday. Fresh companies came up and melted away with surprising rapidity. The officers of the newly arriving companies were ignorant of the arrangement of the

trenches, and consequently General Tretyakov himself had to show them the way and lead their companies into the fight. With marked rapidity and skill he led fresh troops to the most important and dangerous points, and to his action it is due that this most determined assault was gloriously repulsed. His most able assistants at this time were Captain Stempnevski and Ensign Ermakov.

So many shells fell on the top and the rear slope of Visokaya that the wires connecting the hill with the Fifth Regiment headquarters and with the town were broken several times. The behavior of the men of the telegraph company was beyond all praise, and again and again, under heavy fire, they repaired the damage and restored communication. Several of them were decorated on the spot by General Kondratenko for their bravery.

When the telephone was out of action, reports were sent by mounted volunteers. For instance, at 10.30 a. m., when affairs on Visokaya were in a very alarming state, General Tretyakov desired to get into conversation by telephone with General Kondratenko at the Fifth Regiment headquarters. He had just reached the telephone (commandant's) blindage when an 11-inch shell fell so near that it damaged the roof of the blindage and cut the wire.

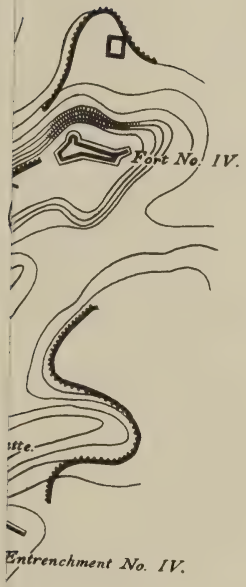
On this General Tretyakov called a mounted volunteer, and sent by him an urgent message that the trenches were wrecked, losses heavy, and reinforcements necessary. As no paper was ready to hand, he wrote this message on a stone.

Owing to the necessity of economizing shells, the Russian artillery was unable to engage with that of the Japanese, and fired comparatively seldom, and then generally at the attacking infantry. The Japanese artillery consequently paid little attention to concealment from view or cover from fire, and, posted within easy range, were able to shell the Russian trenches point blank from morning till night, thereby adding considerably to the difficulties of the defenders. As many as 30 field and mountain guns stood in the open, on the spurs of the Jagged Hills, and in the Ravine near Louisa Bay. A Japanese battery standing on Long Hill, at a distance of 1 to 1 1-3 miles from the trenches of Flat Hill, caused particular annoyance.

Picture to yourself the state of mind of a rifleman sitting in a trench which is under continual fire from a battery from morning to night. The dust rises in a thick column and fragments of sandbags fly in all directions. He sees one after another of his brave comrades perish without being able to cause any hurt to the enemy, and with bitterness in his soul awaits his turn to die like his comrades, ingloriously, unnoticed.

The enemy is meanwhile suffering no loss, rifle bullets will not reach him, and the artillery is silent. The rifleman prays to Heaven that the enemy will attack, so that he may at any rate have the satisfaction of seeing them, firing at them, and possibly killing or wounding some of them. But they sit quietly in their trenches at 30 to 50 paces away, and wait until their artillery shall finally have wrecked the trenches and killed all the defenders.

Of course the men, through their officers, sent urgent entreaties to the artillery to shell such and such a battery and sweep it out of existence. Messages of this description daily came in without end to the headquarters of the Fifth Regiment from various parts of the position, and were passed on at once to the various forts, entrenchments, and batteries. But they were not complied with, as General Biely, finding that his shells were running short, had limited all


Fort No. IV.
tte.
Entrenchment No. IV.

PLAN OF FIRST DIVISION
OF
WESTERN FRONT LAND DEFENCES
PORT ARTHUR

guns to five rounds each per diem. During the main attacks more rounds were fired, but only with special permission from General Biely. Only the Baranov and the Hotchkiss guns had plenty of shells, but these guns were of small range, and the Baranov guns had the additional objection that they used black powder, and the smoke at once disclosed their positions. Consequently, in a work with five or six guns, the artillery commander had to limit himself to firing only from 25 to 30 shells daily, and he therefore considered it his duty not to be drawn into firing at small targets, but to reserve his allowance for use against storming columns, and, with every desire to help the infantry, was obliged to refuse to fire at their request. Occasionally one would take pity and fire two or three rounds, but although naturally these few rounds would do little harm to the enemy, nothing could exceed the delight of the riflemen in the trench. They would exclaim ''God bless and preserve that battery!'' and with this small encouragement would accomplish their painful, unseen tasks with fresh courage.

To add to the troubles with which these hardly-tried men were overwhelmed, their very trust in their rifles in this miserable fighting went from bad to worse. Cases occurred in almost every company when, at the moment of a Japanese attack, some rifle refused to act. One can hardly appreciate the horror of a soldier who in a critical moment finds that his rifle, his one and only hope, has failed him. This was caused by the fact that the bursting shells filled the air with smoke and dust, which, in the course of a prolonged bombardment, was driven in such quantity into the mechanism of the rifle that it often made it impossible to turn the bolt.

The Japanese, who were waiting quietly in their parallels at a distance of some 30 paces from the trench, would seize a favorable moment and rush forward to the attack. The Russian riflemen, whose arms were kept ready loaded, were able to fire one shot (though this was not invariably the case, for there were many misfires), but on attempting to reload they would find that they were unable to work their bolts, and so were obliged to rush upon the enemy with the bayonet, without first weakening him with their fire.

And so the men lost confidence in their rifles and took the more willingly to hand grenades, which did not fail them at the critical moment. By the 30th of November they had taken such a liking to them that they used them almost exclusively, and with great success in repelling attacks. On that date alone as many as 7,000 were used on Visokaya Hill alone, and as this expenditure was greatly in excess of the supply, General Kondratenko, when deciding to send up the seventh thousand, begged the men not to waste them, but to economize them as much as possible. The word ''begged'' is used intentionally, for the ordinary form of General Kondratenko's orders was ''Please, such a one, I beg of you to do so and so.''

The grenades were mostly made in the workshop of Lieutenant Melik-Parsadanov, but Naval Lieutenants Podgurski, Vlasiev, and others also made hem, and 800 were prepared by Ensign Ermakov.

The bright sunshine on the 30th of November inspired everyone with confidence and a firm belief in success. Each worked honestly, fearlessly, with a eeling that the luck was with him. The gallantry both of the riflemen—espec-ally those of the Fifth Regiment, who felt that they must maintain their plendid record and show themselves braver than the rest in the presence of

their commanding officer—and of the sailors, was unceasing. A circumstance which contributed to this good result was that, whether acting on his own initiative or on a hint from General Kondratenko, General Stessel sent the former more than a hundred decorations of the Military Order, with which to reward on the spot any who distinguished themselves. This idea gave brilliant results.

At the beginning of the war the men who came into notice in sorties and by deeds of valor, and the wounded who returned to the ranks, were recommended for decorations, but the recommendations were pigeon-holed by the various staffs. For example, those of the Fifth Regiment, some dating even from August, were resting peacefully in the headquarters of the Fourth Division and were eventually collected by Colonel Dmitrevski, the chief of the staff o that division, and sent back to the regiment to be arranged in a general roll b companies, and in chronological order of the fighting. It was bad luck tha the few invalid clerks, who could be spared from the ranks for work in th Fifth Regiment office, had to sit up all night to complete the list, but it was still greater misfortune that the men, not receiving their rewards and hearin grumbling in the dug-outs at the staffs and headquarter offices, began to los the hope of ever getting any rewards, and when they saw cases of less distinguished men elsewhere receiving rewards, they lost confidence in the justic of the authorities in considering their actions. ''*Bis dat qui cito dat.*'' Me volunteered for dangerous enterprises, dreaming that if they escaped aliv they would adorn their breasts with the valued crosses of St. George. The performed the exploits, returned alive, were recommended . . . and tim passed and the rewards remained a dream! Almost everyone had distinguished himself somewhere, and yet no one had got anything. They felt i jured, and ceased to volunteer for sorties. They began to say straight ou ''Where there are no rewards, do not ask for volunteers; we will go in ou turn.'' And yet the whole success of sorties depends on the men being volu teers, as these alone have the necessary pluck.

In this connection the following order, published by the staff of the Four Division, may be mentioned: ''Only attacks are to be counted as fighting; t daily interchange of firing is not to be so considered.—Colonel Dmitrevski.'' was consequently forbidden to recommend for decoration wounded men w remained in the ranks during the daily firing, although by their action they r the risk of being killed or again wounded.

But as soon as the men saw the possibility of obtaining rewards witho endless delays, there awoke in them a fresh desire for distinction, and m seriously wounded went back to the ranks after having their wounds dress while the numbers who offered themselves as volunteers for even the m dangerous enterprises were so large that it became necessary to cast lots decide who should be taken.

Tretyakov, to whom Kondratenko entrusted thirty of these crosses for tribution in any cases which might come under his observation, was able report as follows: ''Crowds of wounded are returning to the ranks, and ma men are volunteering for the most dangerous undertakings. Those who h received decorations, by their courage and self-sacrifice, are splendidly fluencing their comrades.''

The fighting on Visokaya Hill excited the liveliest interest among the habitants of Arthur, and the streets of New Town were filled with watch

who anxiously followed the progress of the fighting. The Commander-in-Chief was not satisfied with the reports of observers who were following the fighting with field glasses from the Fifth Regiment headquarters, but called for information by telephone from the hill itself, and also from Pigeon Bay, whence its western slopes were visible. With all attention so engrossed upon the fighting, Kondratenko did not forget the necessities of those under him, and made arrangements to provide for their wants.

Deeply regretting the error of the 28th of November, when the rations had come up too late, he constantly enquired if the men had been fed and whether provisions had been sent up, and on the 29th of November he secured a whole horse from the Supply Department, and arranged on the 30th for it to be boiled and cut up into rations, and in this form sent to Visokaya Hill, so that each man up there could draw his portion of bread and meat, and returning to his trench could eat it at his leisure. The value of this consideration was appreciated by the men who had been starving for several days.

At this time the men were getting half a pound of horse flesh twice a week, and on other days only plain porridge and tea, with bread or biscuits. During the fighting it was very seldom possible to get hot food, partly because only two men could be spared for work with the kitchen—a cook and his mate, one of whom had to draw the rations—and these were insufficient to get through the work, and, partly because when the food was ready the fighting prevented the men from attending to it, and when an interval of quiet occurred the food had disappeared, it had either gone bad or had been thrown away for want of vessels to keep it in.

The hot food also gave a lot of trouble, as the men had to go down the hill to get their rations from the kettles, and after eating it had to climb the hill again to their trenches. This took a lot of time, and during the fighting there was no time to spare; each minute was precious, as it was necessary to be constantly prepared to receive the enemy. Consequently Kondratenko's idea of issuing cold cooked rations proved very convenient, as two or three men were able to bring up the dinners for a whole company. The gratitude to the General of ''his overworked and uncomplaining little warriors'' knew no bounds.

In many treatises about Port Arthur (all of which, it must be admitted, emanated from one source) an incorrect idea is given of the services of General Kondratenko. The authors endeavor to give him the character of ably carrying out other men's ideas, but this is incorrect. The author of this narrative, who was present with Kondratenko frequently from morning to night in the Fifth Regiment headquarters, both saw and felt that all the wise and inspired arrangements made by him were attributable to himself, and to no one else. He usually first made the arrangements and afterwards reported them to his seniors.

After repulsing the attacks on this day, General Tretyakov was wounded in the back by a splinter and also bruised about the head; but recognizing how great a blow, both materially and morally, his departure would be for the garrison, he paid no attention to his wounds, but remained on the hill doing his duty and earning fresh distinction. When they tried to tell him that in the interests of his health he should go to have his wounds dressed, he answered that he could not consider himself at such a time, when the fate of his position,

and incidentally of all Arthur, was in the balance, and that it was not in his power to abandon the hill on which his brave regiment was expiring.

The same shell which wounded the General also struck down the commandant of the hill, Captain Stempnevski I. After beating off the assault of the Japanese, Tretyakov had just sent a report of what had occurred, and he and Stempnevski, with a few other officers, were standing in his look-out, looking back at a group of men who were collected round the dressing station under cover of the hill. Stempnevski, who had remained with the General and aided him most efficiently in repelling attacks, was in the act of making an entry in his notebook. He had been very careful in noting down every event as it had occurred on Visokaya Hill, and his notebook was a most valuable document, full of details of this historic defence; but, unfortunately, after he was wounded it was left in the telephone blindage, and eventually lost. And so this gallant and methodical worker was employing a spare moment in making notes of the attack just repulsed. Many of the wounded were also crowded close by, having their wounds rapidly seen to in a small niche.

Just then an 11-inch shell was heard overhead, and before anyone could move it struck the edge of the slope and burst with a deafening report almost in the middle of the group. The force of the explosion threw Tretyakov into the air and then dashed him down so fiercely that he did not at once recover his senses, covering him with earth and small stones. All around, in all sorts of attitudes, and lying one upon another, the whole group lay motionless, and underneath them lay Stempnevski. On all sides were heard groans and harrowing sighs. At the General's feet several of the men lay dead, and with them Ensign Reshetov, of the Second Company, Fifth Regiment, and a white-coated naval engineer, sitting on the ground, clutching with both hands at his left groin, was crying aloud with unbearable pain. After about a minute the surgeons, with their assistants and any riflemen who happened to be at hand, were busying themselves among this heap of living human flesh.

General Tretyakov with some difficulty raised himself. They bore the engineer to the dressing station close by, and placed Stempnevski in the niche The General went up to him and asked him ''What has happened to you, Stanislav Julianovich?'' ''I am badly bruised in the back; I can hardl breathe,'' answered Stempnevski, closing his eyes. He lay pale and motionless suffering severe pain. ''You must be taken to the dressing station.'' ''No, beg,'' answered Stempnevski, and was left lying in the niche. After about a hour he was carried from the hill, and Tretyakov felt that he had indeed los his right-hand man, for Stempnevski knew Visokaya Hill as no one else kne it, every blindage, every traverse, every yard of it, and therefore his loss was grievous blow to the General.

By the heroic bravery of the riflemen and sailors, and above all by Tretyakov's skill in applying this quality of the men, and in sending them in timel support of the points where the danger was greatest, this most persisten attack was brilliantly repulsed, in spite of the overpowering superiority of th enemy in both infantry and artillery, and the perseverence with which the had pressed up the hill for four hours continuously. All Arthur rejoiced at th success, and the name of Tretyakov was brought into high esteem. Genera Kondratenko repeatedly called him ''hero'' and ''brave man,'' and the Fift Regiment felt great pride in their commanding officer.

The Japanese, exhausted with their four hours' fighting, were driven back, and after midday drew off, and peace lasted for over an hour. Then again fighting burst out, at first artillery fire, and at about 3 p. m. the infantry again attacked Visokaya Hill, and, as in the morning, pressed up it with astonishing persistency. The Russians were so exhausted by their long fight without rest or food that they could hardly move, and for want of reinforcements their position became extremely critical.

As every man who could safely be taken had already been withdrawn from the neighboring positions, General Irman decided upon a risky expedient, namely, to bring up immediately the First Volunteer Detachment, Fifth Regiment (80 men), from Entrenchment No. 4 to the Fifth Regiment headquarters.

General Kondratenko reported the want of reinforcements to the staff of the Kwantung Fortified Rayon. At 4.30 Colonel Reiss informed him by telephone that General Stessel advised him to take the fresh troops from Division Hill and replace them by the exhausted troops on Visokaya, as owing to the importance of the latter it would be better to sacrifice Division Hill or Panlunshan.

In accordance with this, the Third Company and half of the Seventh Company, Fifth Regiment, were at once sent for, and it was ordered that the trenches of the Third Company should be occupied by 49 men of the Ninth Company, Twenty-seventh Regiment, while those of the Seventh Company, and also those from which the Fifth Company had been removed on the 30th of November, should be very thinly held by the remaining half of the Seventh Company.

At 4.30 the following information was received by telephone at the headquarters, Fifth Regiment: "To General Kondratenko. Copy of Official Report No. 1937, from the Port Commander. The Port Commander communicates herewith news, collected from Chinese sources, that the Japanese will attack to-day and to-morrow, as these are their lucky days. Their killed number 11,000. From the north the Russians are advancing in relief; they took Samson and stormed Kinchow several days ago. The number of killed on both sides is very great, but the men keep up their spirits. The Russians have yellow epaulets and un-Russian faces.—Staff-Captain Postnikov."

This news was at once passed on by telephone round the positions, but hardly anyone believed it. And yet the yellow epaulets were known to be the mark of the Trans-Baikal Cossacks, and the un-Russian faces seemed to confirm this, as the larger portion of the Trans-Baikal troops were Buryats, of Mongol race; while in Port Arthur there had been for some time confused rumors that a strong force under General Sakharov was advancing to their relief, and that this force included many Cossacks and cavalry generally.

It is not known who was responsible for spreading these rumors, but fresh ones appeared every minute in Arthur, and especially at first had a salutary effect upon the garrison. For example, in August, 1904, when the Japanese for a whole week had been attacking Port Arthur in a most persevering manner and matters began to look bad for the defenders, news flew round the town that the Vladivostok squadron was bombarding the eastern coast of Japan, that they had burnt the Port of Yokohama, that in Tokio alarm was felt at the nearness of the Russian squadrons, that the Japanese could not get sufficient men to complete their armies, that they had no money for carrying on the war, that the people were murmuring against the increased taxation and would not

take service in the armies, but demanded the immediate discontinuance of the war. It was also rumored that a Japanese squadron had sunk a German ship, and that to hide all traces of their crime they had saved no one, but that a passing French ship had picked up three men, and now France and Germany were despatching their fleets to punish Japan and demand satisfaction. They said that the Russian Manchurian Army was pressing the Japanese from the north; that the Mikado did not know how to remedy his misfortunes, and ordered that Port Arthur should be taken at all hazards, in order that he might discuss conditions of peace with Russia on equal terms!

These rumors had appeared creditable because the Vladivostok Squadon had already sunk a Japanese transport which was carrying siege artillery to Port Arthur, and from this everyone looked upon the Vladivostok sailors as heroes, to whom the bombarding of the Japanese coasts would present no extraordinary difficulties! Everyone willingly accepted the rumors, and the spirits of the garrison rose forthwith beyond all comprehension.

Without attributing to these rumors the whole of the Russian success in repulsing the August attacks, it would not be fair to deny them a share in the general result.

But as time went on, and so far from being verified the rumors began to be replaced by the sad truth, they were less readily credited. There is no doubt that those in command at Arthur would have been glad to refrain from publishing these rumors, and would have revealed the truth to the garrison if the truth had been at all consoling!

And so on this occasion the favorable news did not produce on men harassed with this unequal struggle the strong impression which was intended, but there certainly were some who, if they did not believe, at any rate did not dispute the possibility of the approach of a Russian army from the north.

Meanwhile the fighting went on; Tretyakov, in spite of his exhaustion, made use of all available resources with extraordinary skill, and with incredibly small numbers somehow or other supported the mad onslaughts of the Japanese.

To add to their troubles the growing darkness further aggravated the difficulties of the defenders. Nerves harassed by the four days' fighting portrayed to the men all possible horrors. Thus those on the extreme flank kept on thinking they were being turned; some saw Japanese already in their rear, and misled their commander by their unverified reports. About 9 p. m. the enemy looked like breaking off their attack, yet they did not retire, but lying down very near the Russian trenches, kept pelting them with grenades.

Tretyakov's report at this time to Irman gives a good idea of the condition of the defenders. This is what he said: "The enemy are bombarding us heavily with grenades, and keep the men in a state of tension; it is quite impossible to work, the sailors are leaving their places without permission under various pretexts, in spite of orders. Unfortunately, all detachments are intermingled, and the officers are ignorant of the ground and the positions of the trenches; for me personally things are very difficult, the men refuse to move, and, worst of all, I am utterly hoarse and deafened from my bruises."

The complaint against the sailors was really deserved by them, for, compared with the riflemen, they were less well disciplined and less enduring. On Visokaya Hill detachments were intermingled, many of the officers had fallen, and superintendence had fallen entirely on non-commissioned officers. The

sailors did not like coming under their orders, and often utterly refused to obey them, which provoked quarrels and complaints. The sailors were brave; they charged boldly with the bayonet, and by their valor earned a splendid reputation; but when the Japanese fell back in order to rest and to weaken the Russian defence by the fire of their artillery, the sailors did not consider it their duty to sit still in the ruined trenches, and many of them went away under various pretexts.

During this fighting on Visokaya Hill, probably on the 1st of December, cases occurred like the following: General Tretyakov sent a company of sailors, under Midshipman Samoilov, to drive the Japanese from the left redoubt. The sailors went boldly to the attack and drove back the Japanese, but then they themselves dispersed. After an hour the General sent Ensign Ermakov with some order to the left redoubt. The latter went off, but came back again quickly with the report that there was no one there! Tretyakov promptly sent a section of riflemen from the reserve, and spent any amount of trouble and anxiety in looking for the sailors. On another day the same sailors again behaved gallantly in an attack, and again earned commendation.

The riflemen were also very brave, but they had not the *élan* of the sailors; this was not their fault, but due to the different conditions under which they were serving: 1, the sailors were better clothed; 2, they were sent to work for definite periods, while the riflemen worked continuously, because the Japanese were always damaging their trenches. In these cases of course the sailors referred to are not those in companies and detachments which were always employed on the land front, as these served exactly like the riflemen, but those sailors who belonged to the ships, and who formed the general and last reserve, being only sent to the positions on the occasions of especially serious attacks; 3, the sailors were housed in barracks and the riflemen in the trenches; occasional shells flew over the barracks, but the trenches were subjected day and night to the fire of mines, shells, grenades, and machine guns, directed especially at them. The sailors' barracks were situated comparatively far away from the Japanese, while the attackers were within 15, or 30, or 50, or 100 paces of the trenches, so that the barracks were safe from those sudden attacks for which the trenches were only too conveniently situated. From this it will be seen that the riflemen, if they managed to sleep at all, had to do so always with one eye open. Their slumber was disturbed by shells bursting around them, and by the constant fear and anxiety of sudden attack. If the sailors' rest was short, they were able to enjoy it to the full. Their sleep was not disturbed by constant firing, they were not worried about sudden attacks; 4, Finally, the sailors received each day salt beef with soup or broth, but the riflemen only twice in the week got a quarter of a pound of horse flesh with their porridge, and on the other five days plain porridge without meat. They improved it at first with Chinese vegetable oil, and later on when this was expended with something else, which the men called paste, but which they did not like, as it disagreed with them abominably.

By these unequal conditions of food, clothing, quarters, work, rest, etc., the riflemen were weakened, reduced in strength, and became so languid that they could hardly drag their feet along. Many found it a very difficult matter to climb the hill, and if it was difficult to move at all, it was considerably harder to advance to the attack. Recognizing this, they set the greatest value on the

cover to be found in the trenches and feared to leave it for a moment; they grew accustomed to the arduous duty, and became trusty and experienced defenders of their trenches. There were no complaints that the riflemen left their posts without permission, but there were complaints against them of another kind—that they "refused to leave them"—through physical weakness.

The sailors, who had better preserved their physical strength, were the best troops for attack, but they were not used to the arduous duties of the trenches and did not recognize the necessity of sticking to their posts. They much preferred charging the enemy to sitting in trenches and perishing from artillery fire.

Besides these there remained a third class of fighting men, namely, those of the Hospital Detachments. The men who joined these detachments had long been accustomed to work among the sick and wounded, who had addressed them always in a most deferential manner. The hospital servants had treated their wounded comrades very unkindly, complying with their requests or not, just as they felt inclined. But the wounded had not dared to complain for fear of making matters worse. Thus the hospital rank and file became full of conceit, and grew accustomed to having things their own way. They were practically unaccustomed to rifles, drill, or discipline. And all at once they were called upon to man the positions!

In the first place their companies had no cohesion. The men knew little of one another, and the higher ranks, officers and non-commissioned officers, knew less of those under them. And therefore complaints were made against the Hospital Detachments that they knew little of their work in the ranks and were not well disciplined. Complaints were also heard from the hospitals. The hospital men had been replaced by Town Guards, who knew nothing about the care of the wounded and had not learnt the hospital orders. They tried hard, but having no training they managed the new work badly and incurred complaints from the surgeons.

When he received the reports above mentioned, General Irman, with every desire to send up fresh troops, had not a single man in reserve. But within a quarter of an hour the First Foot Volunteer Detachment, Fifth Regiment, under Lieutenant Vasiliev, came up from Entrenchment No. 4 and was immediately sent on to Visokaya Hill.

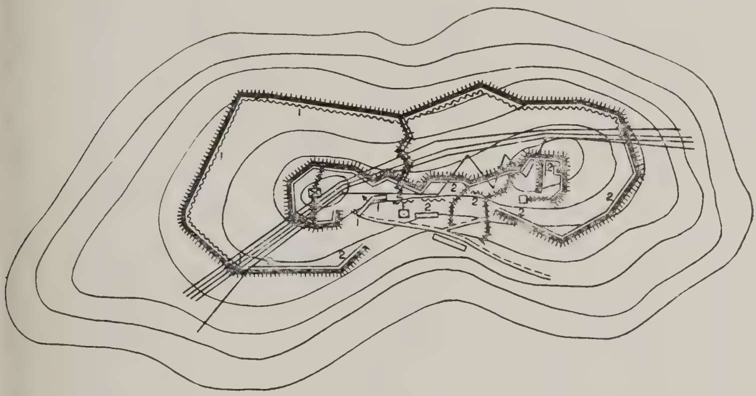
At 9.30 p. m. the Japanese repeated their attack. On this occasion General Tretyakov's report read as follows: "The Japanese are advancing, the reserves are expended, the hill is in danger." The half Seventh Company, Fifth Regiment, under Ensign Moskvin, on arrival from Division Hill, was also sent to Visokaya. The Third Company (137 men) was sent to Flat Hill, but afterward, when it was recognized that that hill stood in little danger, it was sent to Visokaya.

Meanwhile, for want of reinforcements, neither personal bravery nor the activity of the General could stop the Japanese, who pushed back and overwhelmed the weak groups of the Russians, got on to the saddle, penetrated into the left redoubt, and were on the point of carrying the whole hill (see Fig. 5).

Tretyakov had been informed by telephone that reinforcements had been sent up, and he decided to maintain himself somehow. With incredible quick-

ness he ran from one flank to the other, now here, now there, drawing together a few handfuls of riflemen and sailors, and leading them in counter-attack, by which he deceived the enemy, took away their confidence and weakened their impetuosity. By these contrivances he stopped the advance of the Japanese, and when the reinforcements arrived, himself took the offensive. He sent the First Volunteer Detachment to recapture the left redoubt, and occupied himself with restoring order in the center. When the half of the Seventh Company came up he was able to breathe more freely, and detaching part of the men to reinforce the right redoubt, he personally led the rest to drive the Japanese from the saddle.

The First Foot Volunteer Detachment, Fifth Regiment, was formed under Lieut. Vasiliev immediately after mobilization. It consisted almost entirely of reservists from Vladivostok. The men were skillful and experienced, and Vasiliev welded them together and inspired them with his own heroic spirit.



1. Japanese. 2. Russians. ∧ ∧ Scene of the fighting.

Fig. 5. Condition of Visokaya Hill at 9 p. m., November 30, 1904, before the counter-attack

At Kinchow they suffered little, and were withdrawn, among the last, in perfect order. After this Vasiliev left them, having been appointed to a billet in connection with the regimental arms.

In the bayonet fight on Yupilaza Hill, on the 28th of July, the detachment greatly distinguished itself, and lost one officer and forty-four rank and file. In the subsequent fighting from the 13th to the 15th of August, on Three-Headed Hill, it gallantly repulsed the enemy's attack, and charged several times with the bayonet, losing more than half its strength in killed and wounded. Since then the men had served under several commanders, all of whom had been wounded, in fact it is a curious coincidence that not one of its commanders was killed and not one escaped uninjured.

At one time they were commanded by Ensign (now Lieutenant) Vakurin, who wice led sorties from Visokaya, and by blowing up a sap caused great loss to the Japanese. On the 21st of October he was surrounded by them and severely wounded, but succeeded in getting away. On the 13th of November, Lieu-

tenant Vasiliev was withdrawn from his duties in charge of arms to again take command of the detachment.

After their several days' rest in Entrenchment No. 4, the detachment arrived at Visokaya Hill looking fit and cheery. The order to drive the Japanese from the left redoubt gave promise of more bayonet work, with which they were all so well acquainted.

After a short and inspiring speech from General Tretyakov, and with their gallant commander at their head, they dashed forward with the bayonet, thirsting to slay yet more of the Japanese. A wild yell rang over the hill as these 80 chosen fighters, like one man, fell upon the enemy before they could collect themselves and understand what was happening. Was it possible to resist such a united impetuous attack?

All the left crest and the left redoubt were cleared almost immediately. But the Japanese recovered themselves, collected together, and made several gallant attempts to retake the left redoubt; they came against it from three sides, but just then Tretyakov moved on to the saddle with a newly arrived detachment of 2 officers and 160 sailors from the *Retvisan*, and caught them in flank and overthrew them. In other parts also a hand-to-hand fight was going on.

General Tretyakov, in spite of his wound, showed great energy and ability, and once the left redoubt was firmly secured, success soon favored the Russians, and the rest of the hill was again cleared of the Japanese (see Fig. 6).

At about midnight the joyful news flew round Arthur and raised fresh enthusiasm. Many were the messages of congratulation which were sent to Tretyakov, Kondratenko, Irman, and the other heroes of Visokaya Hill.

After driving off the Japanese attacks on the left redoubt, Lieutenant Vasiliev went round his section at the top of the hill, inspiring his men by his words and the example of his personal courage; but at a moment when he was giving some order, with his hat raised on high, a bullet struck him in the right shoulder, his hat fell from his hand, and his men lost their gallant commander. He was at once carried to the dressing station.

Many brave men fell in this unfortunate redoubt, but this must be considered as the price of the preservation of the hill. The Russian losses on the 30th of November were very great. The senior surgeon of the Fifth Regiment Feodor Semenovich Troitsky, worked the whole day, from dawn to 10 p. m., in the dressing station under the hill, and attended to more than a thousand wounded men, after which he lost count. As the slightly wounded either remained in the ranks or went direct to the town without waiting at the dressing station, the total casualties may safely be taken at two thousand men, or eight-tenths of those engaged.

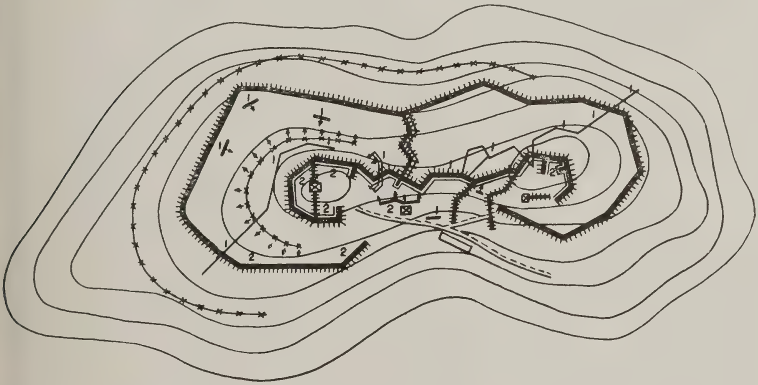
Although stretcher-bearers were summoned from every part of Arthur, ye they were unable to remove all the wounded, and drivers having been requisitioned from the town, some volunteer cyclists came up who, combining together in pairs, fastened stretchers between their machines, and in this way carried wounded men to the hospitals. Others got lifts on travelling kitchens and ammunition carts returning to the town, or found their way back in parties helping one another along. Things were made all the more difficult for the wounded because the Tea Ravine was completely under fire from the Japanese on Visokaya, and movement along it became very dangerous. Cases occurred of wounded men being killed or again wounded in the ravine, and severa

horses, drivers, and stretcher-bearers were also hit while transporting the wounded to the hospitals in Arthur.

After he had sent away his last reserve General Irman was very anxious about the fate of the hill, and could not wait for the joyful news of the repulse of the Japanese, but himself rode up there, taking with him the writer of this account and two mounted volunteers. The newly appointed commandant of Visokaya, Captain Pobilevsky, Twenty-sixth Regiment, accompanied them.

The distance from the Fifth Regiment headquarters to the hill was from 1 to 1¼ miles, and lay along the Tea Ravine, which was now swept with rifle fire from the hill, so that the whole way bullets were singing overhead and falling alongside, but did little harm, as the Japanese, owing to the darkness, could only fire at random. One or two ricocheted at the very feet of General Irman's horse and frightened him so that he jumped to one side, but the General succeeded in quieting him.

Visokaya Hill, on which at that time a desperate battle was raging, presented a most majestic and effective picture. In the dim light of the stars its terrible silhouette was being lighted up by fiery flashes of all kinds.



1. Japanese. 2. Russians.

Fig. 6. Condition of Visokaya Hill, November 30, 1904, after the attack of the First Volunteer Detachment and counter-attack of General Tretyakov

Common shells bursting on the side of the hill turned toward the riders, formed sheaves of brilliant light, from the top and sides of which brown-colored sparks flew in all directions. This light would burst out unexpectedly in various places, and, after brightening up for two or three seconds the sombre repulsive silhouette of the hill, would suddenly die out. The bigger the shells the larger the sheaves of light which burst from them, and the longer they remained visible. At the same time the neighborhood resounded with the crashes of the explosions and the whistling of flying splinters and stones. This was the impression given by the common shell. The shrapnel burst at some distance from the hill, producing long tongues of fire, which were quickly extinguished. The air mines which were thrown by the Japanese, on bursting, threw up enormous sheaves of fire on the crest and on the Japanese side of the hill, and very rarely on the Russian side. The hand grenades thrown by the Russians burst on the far slope, and each with its

brief flash lighted up the crest for a single moment; but the finest effect was produced by the rak-a-rok candles and rockets.

In the darkness of the night it was difficult to carry on the fighting without seeing the enemy; in the eyes of wearied men the enemy appeared to be on all sides, and they fired at random, without taking aim. To overcome this, the officers of the mining company had invented a candle which was about the size of a large radish (in length about 14 to 16 inches, and 3 inches in diameter). The combatants were within 20 to 30 paces of one another, and in places even nearer, and at such a distance it was easy for the Russians to throw a candle by hand with such accuracy that it would fall in rear of the enemy and show up their figures distinctly against its light. Some of these candles burnt with a bright red, uncanny light, while others gave a white light, like that of acetylene gas, and they weirdly lighted up the crest of the hill, as it stood out darkly against the lighter heavens. Each candle burnt for a minute or somewhat longer, and its burning was accompanied with the continuous crackling of the Russian rifles.

From time to time also rockets soared into the sky, but they proved less serviceable to the Russians, because bursting overhead they lighted up both combatants equally.

By all these lighting effects Visokaya Hill was illuminated in an extremely varied and beautiful manner.

Close up to the hill in the head of the ravine was an enormous accumulation of men. Some were boiling something in kettles, others were eating something, or drinking from their water bottles; around a belated travelling kitchen a group of cooks was collected, and these as usual were jostling and abusing one another. Near a dressing station there was a crowd, chiefly of stretcher-bearers and wounded. Such groups need not have attracted attention, as both dressing stations and kitchens are natural adjuncts to the rear of a position. But besides these, on both sides of the road, with their heads on the sides of the ravines, men of all sorts of detachments lay and slept side by side, and so many were there that General Irman asked who they were. At first the writer thought they must be the dead, but a touch convinced him of his error—they were neither dead nor even wounded.

On being roused some of them were found to be so utterly exhausted that no intelligent answers could be got from them, while others said that they had been sent down from the hill because they suffered from night blindness and became useless at nightfall. But others, who were having a comfortable tea round a small fire, had no better excuses than that their eyesight was naturally bad, while others said that they were suffering from slight wounds, but were not allowed to go to hospital.

It may be mentioned here that subsequent enquiries elicited the fact that it actually was the custom to send down at night those who suffered from night blindness; but there were not very many of them, although as the men became weaker the number of sufferers progressively increased, until out of every five riflemen three were suffering from night blindness, while among the sailors the percentage was somewhat less; yet all were not sent away, or no one would have been left to defend the hill, and there were sent down only those who had long been sufferers from this disease. By day these men returned to the hill, but not all of them, some stayed on all day under the hill. As to those who

said that they were wounded, it may be remembered that on the 29th of November parties of convalescent wounded were sent out of the hospitals to form a reserve. The strongest of these had been sent to Visokaya, but having crawled as far as the hill, some of them were quite unable to climb up it, and so remained at the bottom.

During the 1st and 2d of December the Japanese became quieter, and good order was established in rear of Visokaya Hill.

On mounting the hill General Irman and his escort learnt that the assault had been finally repulsed, and that the whole of the position was, as at first, in possession of the Russians. Rifle fire was heard occasionally, but grenades and shells fell continually, though in considerably less quantity than by day.

Stumbling up the rocky slope and over heaps of rubbish, they eventually reached the top of the hill, and here the picture was very far from being as enchanting as it had been from afar.

Visokaya Hill had completely lost its original form, and presented to view a mound of broken stones and fragments of wood, rags, and corpses. The 11-inch shells on striking the rock broke off great blocks, which successive shell broke up into smaller pieces, so that by the 30th of November no more blocks remained, and only small rubbish, which covered the face of the hill to a depth of about 2½ feet.

Of the forty-three blindages, by the 30th of November only two on the left flank remained uninjured. A shell had even struck the edge of the commandant's blindage, which was also the telephone room, but it had fortunately been only a 6-inch, and had not wrecked it.

The rest of the works, such as the shrapnel hoods, were completely destroyed; in several of the blindages several shells had fallen, and these had converted enormous beams into awkward chunks and rubbish.

In order that the reader may appreciate what a ruined blindage looked like and with what horrors its destruction was attended, the following report of Sapper Peter Oleinik, of the Kwantung Sapper Company, is published in full:

"I do not remember the date, but one evening an 11-inch shell wrecked a blindage on the left flank of Visokaya. They at once sent for us, nine men of the Sappers, to dig it out. When I reached the ruined blindage a terrible picture met my view—almost in the very middle of the blindage there was a crater 5 feet deep and 10½ feet wide, from the midst of which, as well as from the entrance of the blindage, rose the smoke of smouldering mattresses and sandbags and the suffocating stench of the gases of the explosion. From within came groans, wails, and cries for water and help. These cries ended sometimes in heart-breaking petitions, sometimes even in abuse. The first to whom my attention was directed was a junior non-commissioned officer of the Fifth Regiment; he lay on his back; his head, arms, and the upper part of his chest appeared from under the ruined blindage, but the rest of his body was buried and so crushed that he in vain struggled to free himself from under the frightful mixture of earth, beams, sleepers, rails, and iron sheets. We fetched three buckets of water, and when we had extinguished the smouldering sacks and mattresses we began to dig out those who were buried alive. We got out the non-commissioned officer first; he was badly crushed and had both legs broken. As we reached the others, we became more horrified; all were

badly mutilated, almost all had arms and legs broken and their hair burnt off. One had his head completely crushed, but all showed signs of life. There were no stretchers, so we removed the sufferers in cloaks, in which many died at once; a few of the men were only badly crushed, but without any limbs broken. When no more groans were heard we stopped work, assuming that all the rest were dead.''

There were sometimes as many as ten to twelve buried in the ruined blindages under splinters of wood and stones. During the fighting there were neither time nor spare hands to dig them out. During the night fresh trenches were built up over the old ones of sacks filled with the rubbish. These trenches in their turn were very quickly wrecked, and from them pieces of the sacks flew like cloths over the whole hill. And so the hill had a very unattractive appearance, no trenches, no cover, only deep craters and a universal heap of rubbish. General Irman first of all turned toward the commandant's blindage, but Tretyakov was not there; he, after driving off the Japanese and going round the position, lay down under a light shrapnel hood which had accidentally escaped injury; he was half lying, resting his head on a stone and apparently dozing, but at Irman's approach he got up, clad in a short black fur coat, and greeted him.

Weariness and exhaustion, already giving place to complete apathy, appeared in every feature. His face and beard were covered with a thick layer of dust, but his ever bright kindly eyes, though bloodshot, to some extent animated his face. He had been deafened by his contusions, and from tremendous shouting all day he had lost his voice and spoke very softly. Besides this he had a splinter of shell in his back and had had no time to get it dressed. All this showed that more had been taken out of him than would have been expected from an ordinary man, and that he, more than anyone, required rest.

The second in command to General Tretyakov on Visokaya Hill was Lieutenant-Colonel Seifulin, Fifth Regiment, who had arrived on the hill after Stempnevski had been wounded, and was evidently less fatigued than his commanding officer.

''Now, as you see, there is a lull,'' said Tretyakov, although this was by no means evident, for in reality grenades and shells were bursting all around; but this was really a lull when compared with the hell which had existed on the hill during the whole day and evening.

Passing round the hill, Irman and Tretyakov turned into the telephone blindage and, sitting on the bench which had served Captain Stempnevski as a bed, began to give their opinions on the matter of Visokaya Hill.

General Irman was of opinion that Visokaya expended too many of the reserves, of which there were really none to spare.

General Tretyakov at first only listened, but later, when Irman asked him what he thought about the fate of the hill, he said that its days were numbered, that they could hold it for three to five days more, possibly for a week, but with great loss, and in the end it must be given up, because there would be no one left to defend it. Its only chance of safety was that the Japanese might suspend their assaults for a week or two; then it might be re-fortified, even to a small extent, and new troops collected. But this is just what the Japanese would not do; they were now attacking each day more strenuously.

and in all likelihood they would continue attacking it whatever happened. This they could do the more easily as they were losing comparatively few men, while the Russians from their artillery fire were losing masses.

During this conversation several times riflemen came running up with various reports.

''Your Excellency! In the left redoubt the grenades are all expended; please sanction more.''

''Here are some grenades,'' counting out twenty, ''be careful of them.''

A non-commissioned officer came running up.

''Your Excellency! In the left redoubt we have only seven men left, including two sailors, who will soon go away; please grant a section to enable us to defeat the Japanese should they approach.''

''Send ten men more from the reserve; keep up your spirits.''

''It shall be done, your Excellency.''

A rifleman ran up, out of breath.

''Your Excellency! The Japanese are coming round our left.''

''Where?'' asked Tretyakov, quite calmly.

''There where the slope runs into the ravine, in order to get at us from behind.''

Everyone sprang out of the blindage and, with alarm, peered down the left flank of the hill to where the man pointed.

''There is no one getting round! It is your fancy,'' Tretyakov again answered, calmly and confidently.

''They are getting round, your Excellency! By God, I saw them myself, and the section commander also said so; they are moving on the slope down which you are looking. Why should I tell you a lie?'' answered the rifleman.

''And I tell you that you are making a mistake,'' replied Tretyakov, and he sent off a volunteer to find out if the Japanese were coming round at the place pointed out. After some time the volunteer returned and reported that they were not, but were sitting still in their saps.

''Why did you say they were moving round? Where are they?''

''Marvellous! But they certainly were doing so; I saw them, and the section commander also . . . ,'' murmured the confused rifleman.

''Well, now go and convince your section.''

''It shall be done. Pardon for having disturbed you,'' and he went away.

''They are continually reporting turning movements to me; I am used to it,'' the General explained in the same calm voice, very softly, from his hoarseness. ''The men, you see, are utterly tired. Their nerves are so strained that in the night they imagine all kinds of evil. And it is impossible to blame them—they are all brave—they are heroes!''

''Colonel,'' said the writer to General Tretyakov, ''is it possible that there are only 17 men in the left redoubt, including the reinforcement you have just sent?''

''Probably 17, unless any have since been killed or wounded.''

''But surely that is too few for the defence of the redoubt?''

''What can I do? All the reserves remaining at my disposal are 46 men in rear of the left flank, and about 50 behind the right, and even these I had

difficulty in collecting after repulsing the assaults. Certainly 17 is few, but what can I do? One must keep some for contingencies.''

In the course of a little time rifle firing broke out in the right redoubt. Although there was no immediate call for them,it was necessary to get the reserves ready for any contingency. The writer ran to rouse some men who were lying in a row by the road to the rear, which led from the commandant's blindage near the top of the hill.

''Here, get up quickly!''

''No, those will never get up,'' explained Tretyakov; ''they are dead; the reserve is further on there.''

Just then there ran out of the right redoubt what appeared to be a crowd of scared men. Tretyakov immediately ran to meet them, thinking that they must be retiring. But no, they were only bringing away a few of their own wounded and one Japanese; the bearers explained that the latter had been wounded, but, fearing to show himself, had lain patiently in the redoubt hiding among the dead, until he had been again wounded by a bursting shell, and had revealed himself by moving and crying out. He was taken on to the dressing station. Such an occurrence was rare by December, because both sides had taken to bayoneting their wounded enemies. There were several reasons for this. In the first place, the combatants were embittered by the desperate nature of the fighting and the murderous effect of the weapons. Secondly, it was dangerous to leave a wounded enemy in the trench, as cases often occurred when wounded Japanese suddenly jumped up and dashed at the defenders, and sometimes bayoneted them; probably the Russians did the same; in a word, it was not safe to leave a wounded enemy in the trench, but there were neither time nor spare hands to take him to the dressing station; it was difficult enough to look after their own wounded, in fact, sometimes a wounded man lay in the trench for hours. Thirdly, the Russian soldiers reasoned very simply in this way: To take a man prisoner meant that he had to be fed and treated in hospital; but their own men had nothing to eat and there was no room for them in the hospitals. Besides this the Japanese were causing them to die of starvation, and without pity were destroying the hospitals, although the latter were marked by Red Cross flags, thus showing that they had neither pity for the Russians nor their wounded, so why should the latter pity them? Finally all the men were tired out and could hardly get through their actual work, let alone carrying away wounded enemies, against whom they were bitterly enraged.

And so this wounded Japanese who was taken down the hill to the dressing station was exceptionally fortunate. He evidently fell into good hands when the men were a little calmer than usual, or he would have taken his place among the dead, of whom there were a vast number on Visokaya Hill; almost at every stage there lay corpses or bits of corpses of either Russians or Japanese.

After going round the hill several times, the two Generals passed along the firing line on the saddle and then went down the enemy's side, and came back convinced that in that part very few Japanese remained opposite the Russian trenches. The riflemen and sailors stood in their places like heroes, repairing trenches and keeping up a fight with hand grenades.

Lieutenant Fetter, of the mining company, superintended the engineering

work on the saddle, as this was considerably weaker than the redoubts. Practically no defences remained here, and he was endeavoring to make at any rate a shallow trench with sandbag parapet. Although the 11-inch shells were falling at the rate of one every five or six minutes, Fetter looked after his work with great coolness, standing completely in the open and paying no attention to them.

General Irman did not quit the hill till 6 a. m.

FIGHTING ON FLAT HILL

Though the main Japanese attack on the 30th of November was directed against Visokaya, yet they also attacked Flat Hill with great desperation.

They prepared the way for the attack with increased fire of artillery and mines. The mines had a terribly destructive effect; they blew the men to bits and scattered them with earth and stones in all directions. They absolutely wiped out the parapet of a trench, sometimes forming a breach as much as 10 paces in width, and they consequently had a great moral effect upon the men. Probably the Japanese had not very many of them, as they did not fire them very often, and, fortunately, they were not always successful in hitting the trench itself. The mine apparatus was on Long Hill, at 400 paces from the trenches on Flat Hill.

At 9.30 a. m. the Japanese carried out their attack and occupied the trenches of the Eleventh Company, Twenty-seventh Regiment, and part of those of the Tenth Company, Fifth Regiment, and the Volunteer Party, Twenty-seventh Regiment. The chief attack again fell on the unfortunate section with the dead ground in front of it. On this section, 20 paces in length, an especially heavy artillery fire was concentrated.

The gallant officers of the Tenth Company, Staff-Captain Astafiev and Lieutenant Selikov, said that they would rather die than yield to the Japanese a single yard of their trench, and took all possible measures accordingly. Astafiev had volunteered for the war from the Twenty-eighth Polotsk Infantry, and having taken over the Tenth Company after Kinchow, distinguished himself with it on the 19th and 20th of August at Angle Hill, where the company lost three-quarters of its strength. The First Half-Company lost practically all its men in the bayonet fighting and from artillery fire, but all the time gallantly held its ground, for which it gained the praise of General Kondratenko, who said that the companies of the Fifth Regiment stood "like a rock." Kondratenko ordered all who remained of the Tenth Company to be recommended for decorations, and that their names should be posted in their companies in letters of gold for all time. Astafiev was recommended for the Cross of St. George, but General Fok did not confirm this recommendation, but replaced it by some other award. Astafiev went round the trenches of his company before the fight and urged the men to maintain the high distinction they had won on Angle Hill; he foretold his own death in the fighting, and besought the men to fight as bravely after it as before, so as not to tarnish the glorious fame of their company.

The "unfortunate" section fell to the share of the Third Section, and here Astafiev collected the men who were most skillful at grenade throwing and ordered them to prevent the Japanese from collecting in the dead ground, and

he also ordered that casualties in this section should be instantly replaced by men from the neighboring sections.

When the increased bombardment commenced, both officers were in the "unfortunate" section, and Selikov was trying to cheer the men with jokes, so that in spite of heavy losses the company was in good spirits.

At 9 a. m., close to where these officers were observing, an 11-inch shell fell in the "unfortunate" section, and the scene of its bursting was marked by a heap of bodies. Sergeant Fedorov and several riflemen lay dead, and both officers were wounded and crushed, and each had one leg blown off. Astafiev was unconscious and did not speak again, but Selikov begged to be left alone, as anyhow he must soon die. The men lifted up both their heroes and carried them quickly out of the trench.

Astafiev died in the stretcher on the way to the dressing station, but Selikov (who was a Caucasian, transferred from the Twenty-fifth Regiment) lived for some hours after his wounds had been dressed, and was able to press the hands of the men who had carried him to the dressing station in token of his thanks.

Hardly had they succeeded in removing the officers when the Japanese began to jump into the trench. The riflemen who remained there met them with their bayonets, and all perished in the unequal struggle, and the "unfortunate" section passed into the hands of the enemy.

On this, Sergeant-Major Evseiv lost his wits, and instead of taking ove command of the company, ran to the commandant of the hill with a report o what had happened, and a hospital detachment, which was on the right of th Tenth Company, abandoned part of their trenches without any apparent cause.

Under these circumstances disorder spread among the men of the Tent Company, and some moved to the right along the trench with the intention o retiring, but Sergeant Kominar, commanding the First Section, rushed t meet them, and stopped and calmed them. Then collecting a few resolut volunteers he led them forward, and by skillful grenade throwing compelle the Japanese to fall back; he could not completely drive them out, as by tha time he had only thirty men left, with whom to defend from the front length of 200 paces of the trench.

Much in the same way the Japanese obtained success in two or three othe places, and Flat Hill was evidently in a very critical state; but its comma dant, Lieutenant-Colonel Budyanski, was brave, energetic, and ready in e pedients, and knew his work thoroughly. Collecting all the reserves whom could lay his hand on, he forthwith launched them against the Japanese, an after a desperate struggle which continued with varying fortune till 11. a. m., he finally drove them back, and everywhere reoccupied his origin positions.

At 11.50 he reported that, by the terrible bombardment which had co tinued since dawn, all his trenches were destroyed and a very large number his men killed; in the Stony Redoubt as many as half the garrison h fallen; that the Japanese had made an attack and had occupied part of trenches, but that by his dispositions they had been beaten off, and all t trenches were once again in his possession; and that now he could see that t enemy were concentrating their forces against the center of Visokaya Hill.

After midday the Japanese made no serious attack on Flat Hill, but limit

themselves to demonstrations and artillery bombardment. Lieutenant-Colonel Budyanski, who since the 27th of November had repulsed such a number of Japanese attacks, became famous throughout the garrison, and was recommended for the Order of St. George, with which he was afterwards deservedly rewarded.

December 1.—The Japanese, as usual, increased their artillery fire at dawn, and their infantry recommenced their attacks, but with far less energy than on the previous day. Their tone had notably weakened. They advanced to the attack, not in large masses, but in small parties of about 50 men each, and these attacks lacked the *élan* and persistency of the day before. What generally happened was that some 50 men, with loud cries, would climb out of their trenches and make a dash up the hill; the Russians would overwhelm them with grenades and rifle fire, and they would fall back; after a little time they would repeat the practice. In this way the defenders had to be constantly on the alert, and as they were exposed to a powerful artillery fire the whole time, their losses were considerable. Unfortunately no count was kept f the number of shells which were fired on this day against the hill, but it must have been fully 800, and possibly 1,000.

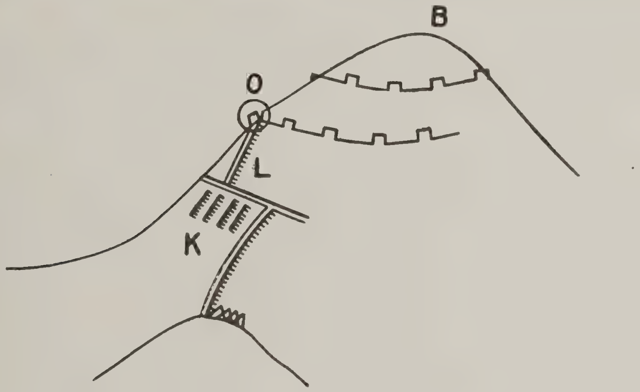


Fig. 7. View of Visokaya Hill from Pigeon Bay, December 1, 1904, at dawn. Eye sketched. Lent by Lieut. Col. Gobyato.

O.—Shows site of blindage occupied by the Japanese on November 28.

K.—Traverses erected by the Japanese to shelter their reserves from artillery fire rom Pigeon Bay.

L.—Japanese communication trench, connecting their sap with the captured portion f the Ring Trench.

Lieutenant Erofiev reported to the Fifth Regiment Staff, from Pigeon Bay, hat about two regiments of infantry were seen to move from Visokaya to Angle Hill, and on toward Louisa Bay; that there remained enough men on Visokaya to keep a few moving about in the Japanese saps and to man the ower parallels, though not so strongly as on the day before, while of the olumns which overnight had been noticed climbing the hill, not a sign was to be seen.

As Erofiev could obtain a good view of the side of Visokaya which was being attacked, his information was very accurate and valuable, and on this

occasion it was decidedly consoling (see Fig. 7, which is a sample of the sketches which accompanied Erofiev's reports).

At about midday the Staff of the Land Defence reported that about two battalions of Japanese were moving over toward the left flank. Two regiments going away at dawn, two battalions coming in the forenoon. Evidently the enemy were replacing the troops who were exhausted in the fighting. They too were worn out, which was satisfactory!

If one considers that two regiments had been relieved and that sufficient troops still remained, one may assume that the hill had been attacked by three regiments; on the Russian side there were never present more than 500 men, and sometimes only 300. It is true that casualties were constantly being replaced from the reserves, but these casualties were caused by the Japanese artillery, and if the reserves are written off against the Japanese artillery, it remains that the 500 wearied, half-starved Russians had been opposed to three regiments of Japanese infantry. As each regiment numbered from 2,500 to 3,000 men, it will be seen that the proportion against the defenders was about 20 to 1.

And these overwhelming masses by continuous fighting during the day succeeded in gaining the very summit of the hill, only to fall back during the night before the charge of two, three, or four fresh Russian companies, which had been meanwhile brought up from the reserve. It was noticed that the Japanese could not as a rule withstand the Russian bayonet charges, and for these the night was most suitable.

The admirers of Japanese bravery may explain their ill-success by the maxim that it is much more difficult to attack a hill than to defend it; but how can they explain that the enormous forces of the Japanese could not hol ground *already taken*, and were driven back by mere handsful of Russia soldiers?

Even Tretyakov, self-sacrificing, gallant, experienced, and energetic thoug he was, could not work miracles. In the opinion of the writer, attentiv criticism of the actions of both combatants at Port Arthur does not confir all the praise which has been lavished upon the Japanese.

Their generals had great perseverance, but the quality of their troops wa not at all superior to that of the Russians. In Manchuria the Japanese wit weaker forces captured the positions because the Russians fell back befor them by order. All were struck with their discipline, order, courage, etc The same Japanese fell back themselves several times at Port Arthur, while a Visokaya, where they met a fine garrison under the direction of a first-rat commander, their ill-success was extraordinary—extraordinary because, afte converting the position into a heap of ruins, and with enormous preponderanc of artillery and infantry, they could not capture the hill, in fact they eve retired before mere handsful of its defenders.

No! The Japanese troops are excellent, but nothing exceptional, nothin invincible, and they do not excel the Russians. They are not exempt fro errors and disorders. Everything depends on the troops with whom they hav to deal. Three regiments were so exhausted in the struggle with the wearie handful of Russians that it had become necessary to give them relief and res Surely this was not victory!

In a report by Lieutenant-Colonel Seifulin, who had temporarily replace

Tretyakov on Visokaya Hill, it was stated that at about 3 p. m. a small party of Japanese, numbering 25 men, suddenly climbed out of their sap and running up to the parapet of the left redoubt opened an irregular rifle fire, and at the same time made fast some long ribbons of paper, which being blown out by the wind disclosed both the line of the parapet and also that of the damaged covered communication trench down the hill. The party was soon driven back by rifle fire, but the Japanese artillery began shelling the spot where the ribbons were blowing about, and struck down several railway laborers and riflemen who were there. Colonel Seifulin ordered the ribbons to be taken away, and when this was done the previous conditions of fire were re-established. Evidently the Japanese had endeavored to point out to their artillery points at which further demolition was required.

The Japanese, who were making an outwork on Visokaya in front of the Russian trenches, worked hard at it all day, and in order to conceal the working parties they lit up wood fires in places so chosen that the smoke driven y the wind concealed them from view. They probably threw damped rags nto the fire; at any rate, whatever they used produced a very thick smoke hich effectually concealed their work. General Tretyakov correctly gauged heir intention and ordered the men to fire into the smoke, but as the actual osition of the working parties could not be seen, the random firing probably id very little harm.

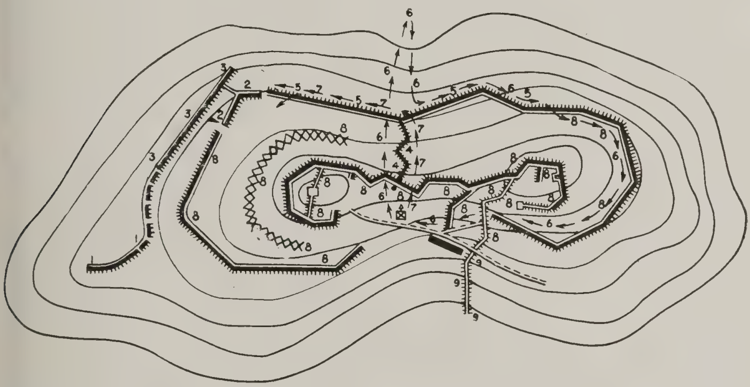


Fig. 8. Plan of Visokaya Hill, showing the events of December 1-4, 1904

1. Trench excavated by the Japanese for correcting their fire on the fleet and the own.
2. Portion of Ring Trench captured by Japanese. The sortie before dawn on the 5th of December was directed against this.
3. Japanese sap.
4. Demolished portion of covered communication trench.
5. Demolished and unoccupied portion of Ring Trench.
6. Route of first reconnaissance on night of December 2-3.
7. Route of second reconnaissance on same night.
8. Trenches, communications, and obstacles occupied and repaired by the Russians.
9. New communication trench constructed by Ensign Ermakov in the nights of ecember 2-3.

At about 3 p. m. the newly-appointed commandant of Visokaya, Capt.

A. I. Veselovsky, with his company, the Fifth, Twenty-sixth Regiment, set out for the hill. On his way he was laughing and making jokes, and his men, taking their cue from their gallant commander, were in a state of cheery good-humor. ''With such a company as ours,'' said the men, ''no place is to be dreaded!'' Their sincere, light-hearted, and honest tone inspired the conviction that in that company there was no injustice, no discontented man, but a strong bond of unity between the commander and his subordinates.

On this day the Japanese also carried out small attacks against Flat Hill, and in one place, as usual, near the ''unfortunate'' section, they had a certain amount of success. The Hospital Detachment, who happened to be there, by moving toward the left evacuated the bays between three traverses, and the Japanese burst into these and thus secured an entrance into the Russian works. On hearing of this, Capt. Baron Geikin began calling for volunteers to drive them out. But among the hospital men no volunteers came forward, and he had to turn to the Twelfth Company, Fifth Regiment, who were alongside, and who at that time, including the wounded remaining in ranks, numbered in all twelve men; he secured three, Sergeant Zakharov, Rifleman Ryabukhin, and Town Guard Tiushev. These fearless men, throwing grenades into the bays held by the Japanese, rushed forward, followed by Geikin and the hospital men. Communication with the neighboring company was reestablished, because few Japanese were left.

Zakharov, Tiushev, and Ryabukhin were taken by Geikin before the commandant, Budyansky, who thanked them, and begged for them decorations of the Military Order. Zakharov had already greatly distinguished himself in the preceding fighting, and had performed many gallant deeds, of which three were especially brilliant, namely, on the 28th of November guiding the volunteers who drove the Japanese from the ''unfortunate'' section; on the 30th of November, after being wounded in the knee, remaining in the ranks, and on the 1st of December volunteering to restore connection in the trench. In all he was recommended at various times for four grades of the Military Order and for promotion to sub-lieutenant; but he was promoted only to the rank of ensign, and received no other grade of the Military Order.

General Kondratenko was able to replace Tretyakov by Lieutenant-Colone Organov, Twenty-sixth Regiment, in order to give him leisure to rest and have his wound dressed; but it was already evening and quite dark before the relie had been carried out, and Tretyakov rode down from the hill to the Fifth Regiment headquarters. Kondratenko, who had spent the whole day there asked him many questions, and deliberated with him for many hours as to th fate of the hill, and not till after midnight did the former ride off to hi quarters.

After his departure Dr. Troitsky inspected Tretyakov's wound, and foun that he had a splinter in his back and that the wound was beginning to feste and advised him to go at once to hospital to be operated upon; but he was exceedingly tired and hardly understood what the doctor was saying, and forthwith fell asleep.

The riflemen on the hill meanwhile did their best to clear and repair th trenches and blindages which were wrecked and encumbered with corpses, bu the work made little progress owing to the heavy artillery fire, which wa destroying not only the works, but even the very hill itself.

(*To be continued.*)

RELATIVE ADVANTAGES OF LOCKS, LIFTS, AND INCLINES*

BY

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Laying out the route of artificial waterways of great length is one of the most difficult problems an engineer has to solve; one that is full of responsibilities, but at the same time full of interest.

In selecting such a route, the engineer has to pay due consideration not only to the configuration of the ground and the geological and meteorological features of the locality, but also to the volume and nature of the traffic that may be reckoned upon; according to whether through traffic alone is to be provided for or local traffic also, and whether it will be uniformly distributed over the whole navigation season or confined to a few months only. Other important points to be considered will be a cheap supply of water for the canal and the best method of surmounting changes in the levels.

If a waterway is to be constructed which is to comply fully with all economical requirements, upon which, namely, bulky goods are to be carried at lower rates than by any other known means of transport, especially railways; if, moreover, the canal is not only to benefit its two termini, but also the whole country traversed by it, in that case several alternative routes will have to be studied, plotted, worked out in detail and estimates prepared for them, before the final scheme is selected and the work is carried out. If this preliminary caution is neglected, one must be prepared for disagreeable surprises afterwards.

The question of how to surmount changes in the levels is one of the most important ones in laying out the route of a canal, especially when considerable heights are to be negotiated or high watersheds have to be crossed, as will be the case with various future Austrian canal schemes. One will always endeavor to place the summit reach as low as possible, and as economical considerations will allow, but at the same time one will not shrink, in very special cases, from considering the advisability of deep cuttings or tunnels, if works of this description would enable us to reduce considerably the height of the fall to be overcome and if at the same time a better supply of water could be provided for feeding the canal.

As it is impossible in the case of artificial waterways to overcome heights by gentle, long, and continuous inclines, as in the case of rivers and railways,

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the canal is of necessity to be divided into various lengths or reaches situated at different levels.

The passage from one reach to the other is effected by means of some kind of boat-lifting appliance. It will be in the interest of the boat traffic to limit the number of changes in the levels to what is strictly necessary, without, however, nursing an undue prejudice against these natural but as regards the traffic on, and the working capacity of, the canal, necessary impediments, and without on the other hand prolonging unduly the time occupied in transit.

As regards economy, locks, lifts, or inclines must not increase too much the costs of construction and maintenance or the working expenses of the canal; the route itself must not, in consequence of the system chosen for overcoming changes in the levels, be diverted to too great a distance from manufacturing centers usually situated along the valley, nor from existing inhabited places and human settlements, nor must it be carried along some out-of-the-way country with the sole object of negotiating a great fall in the canal level at some point fixed beforehand.

In order to avoid a crowding of boats at certain locks, lifts, etc., it will be necessary in the first place, in case the traffic is very brisk, to try to arrange that all locks, boat-lifts, and inclines along the whole length of the canal should be of about the same working capacity. If one of the boat-lifts should happen to be of somewhat less working capacity than the rest, it would seriously interfere with the traffic on the whole canal, even if a double shift of attendants were provided for the boat-lift in question and work carried on there night and day, while the working time at all the other lifts or locks was limited to fifteen hours per day, an allowance as regards the length of working day upon which the working capacity of the canal has been calculated.

It is only natural that there should be very few men to be found among the navigation fraternity who would favor the choice of a lift by which boats are raised and lowered dry and not afloat. A boat used on inland waterways is, and always will be, a simple and very lightly built craft, considering the low price at which it must be obtainable, and the heavy cargoes it has to carry with the least possible draught, because it has not only to travel on canals with always an ample depth of water in them, but has to traffic on non-canalized rivers also, in which the water is often very shallow. When transporting boats dry, there is always a risk of starting the joints, when the boats are heavily laden, owing to the variation in the pressure on the side walls; and the want of uniformity in the pressure on the bottom is apt to produce leaks after several trips of that kind If the fact is also borne in mind that the canal is not to be used exclusively by new, but also by old and weak vessels, which might be used for local traffic for instance, it is only natural that all boat lifting appliances are expected to comply with the boat owners' reasonable requirements that their vessels should be lifted afloat, unless inland navigation is to be seriously interfered with.

The system of boat-lift to be chosen must accomodate itself to the configuration of the ground traversed by the canal and must not entail heavy earthworks or other works equally costly. The works, moreover, must not be endangered by sudden frosts, or by the action of the wind or rain, and must

besides, remain in perfect working order so long as it is possible to carry on the traffic on the canal.

The working of the boat-lift and its upkeep must be easy, sure, and not too costly. Another essential condition is that it should be possible to carry out with ease and expedition all necessary repairs, especially those to be executed after an accident—which can not be avoided altogether in practice—so that in the case of a breakdown of the structure, navigation on the canal should not be stopped for any undue length of time.

Of all appliances hitherto constructed for lifting vessels of large dimensions, the ordinary, but modernized, canal lock has proved itself to be the most perfect in working, if the quantity of water required for locking can be provided at a reasonable cost. The absolutely necessary quantity, however, is very considerable, when the fall is very great and the traffic very brisk, even when saving ponds are provided.

With a properly laid out canal and an appropriate arrangement of locks to suit the demands of the traffic, it is easy to raise boats to a height of from 300 to 400 meters and to lower them again to an equal depth by following closely the configuration of the ground as proved, for instance, in the case of the scheme for a canal from the Danube to the Moldau.

Where the height has to be surmounted *in cumulo* and the canal can not be carried round in easier steps, a flight of locks in double series is the most suitable device to meet the demands of an intense traffic.

If, however, there should be a deficiency in locking water, the engineer who lays out the route can make use of vertical boat lifts worked by floats or hydraulic presses, which have answered well with differences in the levels of from 15 to 25 meters.

It may be desirable under very special conditions as regards the configuration of the ground, to have recourse to other kinds of appliances for raising vessels when working out a canal scheme, especially to inclines, that is, inclined tracks specially adapted for transporting vessels on rails, for which ngenious schemes have been worked out, but which have hitherto only been used for boats of comparatively small sizes.

The question as to what type of boat lifting device should be preferred, or what combination of several different types should be adopted on the same canal for a given volume of traffic, will in every instance have to be settled by a thorough investigation, which will have to be made in reference to the whole length of the canal and not merely in reference to a limited portion of its length.

The object of the present report is to investigate the question, What effect he choice of various types of boat lifting appliances may have upon the workng capacity of a canal and also upon the alignment of its route, on the asumption that similar operations will entail the same loss of time with various ypes of boat lifting appliances. The investigation is based on results pubished on the occasion of the international competition instituted by the Ausrian government in 1903 for a boat lift to be erected at Aujezd on the line of he proposed canal between the Danube and the Oder.

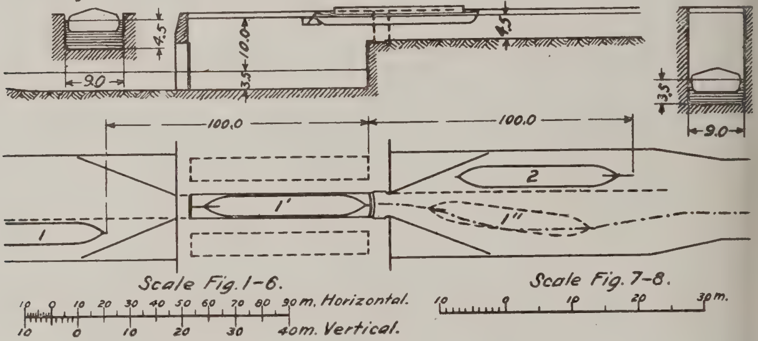
In order to have a safe basis for investigating different types of boat lifts, is proposed to describe the various manipulations and the order in which ey have to be carried out with standard 600-ton vessels, it being assumed at the lock, boat lift, or incline has been constructed in a faultless manner

from an engineering point of view, not as a whole, but also in all its mechanical details; that it is working without a hitch and that the working staff are experienced men. Any advantage due to any improvements introduced in a certain type of boat lift will, by the same right, be assumed to enhance the efficiency of all other types in respect of details of construction to which such improvements may be applicable.

With reference to the lengths of time required for carrying out certain maneuvers or operations, these were estimated upon the basis of data derived from actual practice with existing structures. These data were officially communicated to the writer and confirmed by him by personal observations. In the case of schemes not yet carried out, the allowances for time were estimated on the same basis.

The time required for warping a boat by means of a capstan into the movable tank of a lift, of a net length of 67 m., a width of 8.80 m. and a water depth of 2.50 m. will be reckoned at four minutes; this is the actual time taken by 600-ton vessels at the Henrichenburg lift when the traffic is brisk, and the working continuous. A reduction in this allowance would seem to be impossible in practice, considering not only the inevitable limitation of the dimensions of the space occupied by the water in the tank (Figs. 8a to d) and the resistance due to high speed, but principally on account of the necessarily great precaution which has to be taken that the incoming vessel shoul not strike against the gates closing the end of the tank and damage the (Figs. 2, 3, 4, 5), which would disable the whole structure.

Fig. 7b. Fig. 1. Fig. 7a.



In the case of a lock, on the other hand, we may assume three minutes fo the same operation. This is ample in view of the comparatively large are of the wet section, which may be used (Figs. 7*a*, *b*), and in view also of th solidity of the parts of construction, which are better able to withstand blow from a boat.

The net length of the lockpit is the same as before, namely, 67 m., but th width is 9 m. and the depth of the water 3 m. or even more.

The vessel advances a distance of 100 m. in both cases, when entering o leaving the tank of the lift or the lockpit.

To swing round the vessel to bring it in a line with the center line of th tank or lock (Figs.1-5) we reckon will take one minute in every case. Thi can not be avoided, especially when vessels have to pass each other.

We have not shown in our sketches any unnecessarily prolonged length which may be given to the approaches of the structures, nor any walled pas

sages which may have been kept too narrow for bridges crossing the canal and which may impair the working capacity of a lock.

On the following pages we propose to give the results of our analytical investigations of the question of the theoretical working capacities of different kinds of boat lifting appliances. The maximum effective working capacity may under the most favorable conditions amount to about 75 per cent of the theoretical value in the case of a canal with brisk and continuous traffic, if allowance is made for the various minor hindrances which always take place in actual working.

A. ORDINARY LOCKS

We will assume that all sluices, gates, and capstans are worked by electricity. The necessary current is generated on the spot by water power, a small turbine being provided for that purpose. The gates and sluices are worked from a fixed point.

The upper sill is placed as low as possible (we assume it to be at 4.50 m.) below the level of the upper pool, so that the filling of the lockpit may be effected as calmly and as rapidly as possible; the entry and exit of the boat should be easy; and the current and the fluctuations in the water levels of the adjoining reaches, which are suitably enlarged at the lock approaches, should be reduced to a minimum without any injurious effect.

Lock with 10 m. Fall with Two Saving Ponds. (Figs. 1 and 7a, b.)

I. Time spent by the boat in passing through the lock:

1. Entry of boat from the lower pool into the lock....		3′00″
2. Closing lower gates..................................		0′30″
3. Filling lockpit (1)...................................	4′00″	
Delay on account of making use of the two saving ponds (2)............................ 1′+1′=	2′00″	
		6′00″
4. Opening upper gates..............................		0′30″
5. Exit of boat..		3′00″
Total time..		13′00″

luring which time the boat advances 100+100=200 m.

Thus six minutes are required for lifting the boat and seven minutes for all he other operations.

II. Interval between two boats following each other:

The operations mentioned under items 1 to 5 for the passage of the first boat last....................		13′00″
6. Closing upper gates............................	0′30″	
7. Emptying lockpit and filling the two saving ponds as before..	6′00″	
8. Opening lower gates..........................	0′30″	
		7′00″
Total time....................................		20′00″

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1. Three thousand one hundred cubic meters are taken from the upper pool, and 3,000 ubic meters from the saving ponds, the mean rate being 25.5 cubic meter-seconds; this the actual rate in the case of the well-managed locks of the canalized Moldau. Laurell ckons to fill the Trollhutta locks at the rate of 44 cubic meter-seconds.

2. In conformity with direct observations made in the case of the locks with saving onds of the canal from Charleroi to Brussels. (Report of E. Lefebvre, Dusseldorf, 902.) The designer can regulate at will the time of filling and emptying the lockpit by suitable system and by an adjustment of the dimensions of the sluices and saving onds, and of the area of the inlets.

It is only now, that the lock is ready for the second boat. The interval between two boats is, therefore, twenty minutes, which corresponds, at the rate of 4 kilometers an hour, to a distance of 1,333 meters.

III. Two boats crossing at the lock:

Locking through the first boat took		13′00″
6. Swinging round and bringing into line the second boat in the side portion of the upper reach	1′00″	
7. Entry of this boat into lockpit	3′00″	
8. Closing upper gates	0′30″	
9. Emptying lockpit, etc. (4′+2′)	6′00″	
10. Opening of lower gates	0′30″	
11. Exit of second boat	3′00″	
		14′00″
12. Swinging into line the third boat		1′00″
Total time		28′00″

This is the total time taken up by two boats crossing each other. The lifting or lowering of the boat takes twelve minutes; all other manipulations, sixteen minutes.

Every boat has to wait at the lock 13′+1′=14′ before it can cross another going in the opposite direction.

The subjoined table shows the influence which the fall of a lock may have upon its working capacity. The lock with a 5-meter fall is an ordinary lock, the others are locks with side pits provided with the requisite number of saving ponds so that the quantity of locking water taken from the upper reach should be the same in every case, namely, 3,100 cubic meters. The balance has to be supplied from saving ponds. The delays caused by the latter are reckoned at the rate of one minute per saving pond.

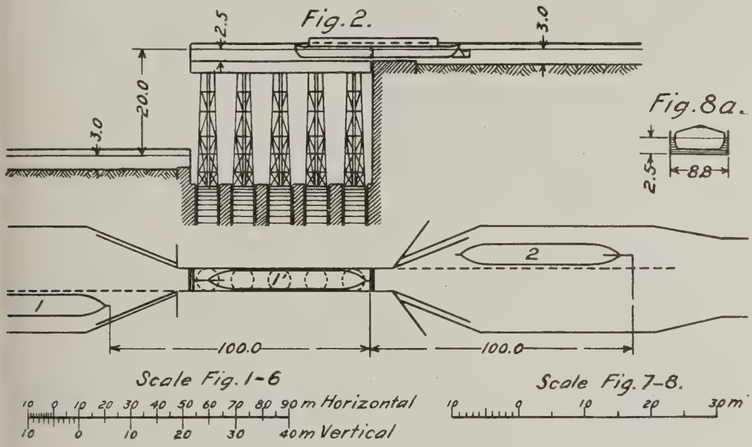
The table shows also the working capacities of double locks, that is, two locks placed side by side, one of which acts alternately as a saving pond for locking water, by means of which a saving of about 40 per cent (theoretically 43.75 per cent) can be effected in water. The analysis was made in the same way as for a hydraulic lift. Allowance was made for the delays caused by the filling of the lockpits at the rate of one minute, as in the case of saving ponds. Two minutes will have to be added to the time occupied in locking in the case of double locks, for the same reason as explained in the case of the vertical lift with movable tank.

Amount of fall	No. of saving ponds	Time required for passing a boat through the lock—			Interval when boats—		Double locks with 43 per cent of water saved—		
		For raising or lowering	For other manipulations	Total	Follow each other	Cross	Time spent by boat in lock	Interval when boats follow each other	Interva when boats cross
Meters									
5	-------	2′	7′	9′	12′	20′	10′	7′	1
10	2	6′	7′	13′	20′	28	12′	9′	1
15	4	10′	7′	17′	28′	36′	------	--------	------
20	6	14′	7′	21′	36′	44′	------	--------	------

Eventual fluctuations in the water level of the adjoining reaches have scarcely any influence upon the time required for locking.

B. VERTICAL LIFTS

a. Floating lift with a single tank, after the type of that at Henrichenburg. According to official information received, at Henrichenburg boats are lifted 14 meters high in two and one-half minutes. The time required for a double locking, that is, for the necessary operations to raise a boat and lower another, including the time lost in entering and leaving the tank, is twenty-five minutes, except unforeseen delays. Only eighteen minutes are, however, required when the boats are warped in and out of the tank by means of capstans.



Floating Lift with 20 m. Fall. (Fig. 2.)

I. The time spent by a boat in passing up the lift may be computed as follows:

1. Entry of boat into tank	4′00″
2. Closing gates, emptying gap, undoing water-tight wedge	1′30″
3. Raising or lowering tank	3′00″
4. Inserting water-tight wedge, filling gap, opening gates	1′30″
5. Exit of boat	4′00″
Total time	14′00″

II. Interval between two boats following each other, as in the case of the ock:

14′00″+1′30″+3′00″+1′30″=twenty minutes.

III. Two boats crossing at the lift, as in the case of the lock, making allownce for swinging into the center line the boats placed side by side:

14′00″+1′00″+4′00″+1′30″+3′00″+1′30″+4′00″+1′00″=thirty minutes.

b. Hydraulic lift with two tanks, one going up while the other goes down, ke the new type of lifts on the Canal du Center in Belgium.

According to the report of M. Genard, the time required for lifting a boat ounted from the moment when a boat arrives at a point 30 meters distant rom the structure in the upper or lower pool, as the case may be, to the

moment when after having been raised or lowered, the boat reaches a point, also 30 meters distant from the work, on the opposite side of the lift, is fifteen minutes in the case of La Louviere lift, the rise of which is 15.397 meters; this includes two minutes fifteen seconds for the ascent and descent, respectively, of the tanks. The latter are of the following net dimensions: length, 43 meters; width, 5.80 meters; depth of water, 2.40 meters; they can accomodate vessels up to 360 tons.

Hydraulic Lift with 20 m. Rise (Fig. 3) for Vessels of 600 Tons

It may be assumed that the various manipulations in this case will take the same time as in the case of a floating lift, namely:

I. Time spent by a boat in going up the lift.

1. Entry of boat into tank	4′00″
2. Lowering gates, emptying gap, undoing water-tight wedge.	1′30″
3. Ascent of one tank and simultaneous descent of the other.	3′00″
4. Making fast, inserting water-tight wedge, filling gap, opening gates and bolting them, setting stopping signals for boats	1′30″
5. Exit of boat	4′00″
Total time	14′00″

II. The interval between two boats following each other is 14′00″—4′00′ or ten minutes only, because while the first boat is leaving one tank, the secon boat can enter the other as it is empty.

III. Time required for two boats to cross. Assuming that they enter an leave simultaneously, and that the raising and shutting of the gates and al other manipulations are carried out at exactly the same moment for both tanks and making also allowance for bringing the second boat into line with th tank, as probably she had to be hauled aside beforehand, the time required wil be 14′00″+1′00″=fifteen minutes.

These manipulations, however, can not be carried out with such exactitud except in very exceptional cases, when all the necessary preparations have bee made for a trial; it will therefore be necessary to add in practice two minute to our estimate.

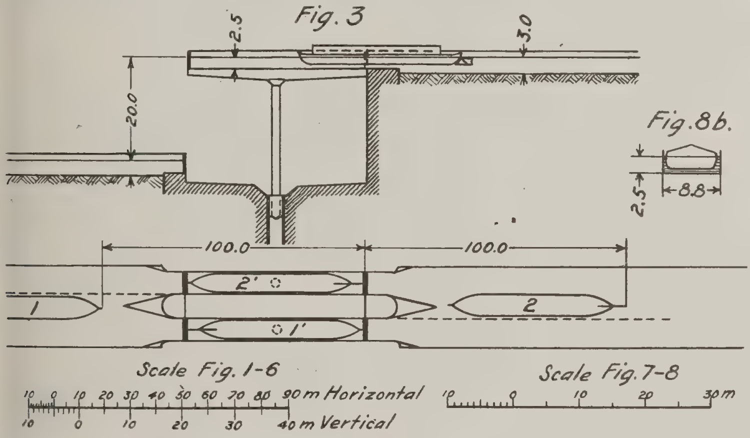
No allowance has been made either in this instance, or in the case of th floating lift, for delays which may take place in the various manipulatio owing to the fluctuations of the water line in the adjoining reaches. Th wind, for instance, may raise the surface of the water in the upper pool by 2 cm. and lower it by that amount in the lower pool. There may be, therefor a difference of 50 cm. in the height of the fall. The adjustment of the wat level between tank and reach requires considerable time, and may therefo further reduce the theoretical values of the working capacities.

The subjoined table shows for the two kinds of lifts in question the i fluence which different falls have upon the effective working capacity wi normal water levels in both reaches. It will be seen that owing to the spe at which differences in levels can be surmounted, the working capacity r mains more or less constant for falls of from 10 to 25 meters.

Difference in canal levels	Floating lift with single tank				Hydraulic lift with two tanks			
	Interval between boats		Time required for		Interval between boats		Time required for	
	Crossing	Following each other	Boat going up or down the lift	Raising or lowering tank	Crossing	Following each other	Boat going up or down the lift	Raising or lowering tank
	m *s*	*m* *s*	*m* *s*	*m* *s*	*m* *s*	*m* *s*	*m* *s*	*m* *s*
10 meters	2 00	13 00	18 00	28 00	2 00	13 00	9 00	14 00
15 meters	2 30	13 30	19 00	29 00	2 30	13 30	9 30	14 30
20 meters	3 00	14 00	20 00	30 00	3 00	14 00	10 00	15 00
25 meters	3 30	14 30	21 00	31 00	3 30	14 30	10 30	15 30

C. RAILWAYS, OR INCLINED PLANES, FOR TRANSPORTING VESSELS

A few canal inclines have been constructed hitherto, but for boats of small tonnage only, of which it will suffice to mention the transverse incline with double track built at Foxton, in England, by Mr. Gordon C. Thomas, which has a gradient of 1 in 4 and has been at work since 1901. The difference in levels to be surmounted amounts to 22.91 meters. Each tank has a length of 24.38 meters, a width of 4.57 meters, and the water in it is 1.37 meters deep; the largest boat they will accommodate is one of 70 tons. According to the report of Mr. Thomas, the partial transport of boats can be effected at intervals of fifteen minutes when boats cross each other at the incline. This entirely agrees with the results of our investigations, if we make due allowance for the shorter length of the boats and the track, and for the smaller size of the gates and tanks which have to be moved in this case. In order to enable the boats to cross each other more easily and more quickly, it would have been advisable to widen both the upper and lower canal ends as indicated in dotted lines in Fig. 6.



In the following estimates of the working capacity of canal inclines of different types capable of lifting 600-ton vessels to a certain minimum height, we

have not included longitudinal inclines with single tanks, nor inclines with dry upper chambers, however economical and advantageous these types may be under certain circumstances, because their working capacities are greatly exceeded by those of inclines with two tanks when the canal is one of large dimensions and the traffic is brisk, although these types may be more costly.

a. Longitudinal Incline with Double Track, 1 in 25 Gradient and 40 Meter Fall

If we consider the advantages, which the various schemes submitted on the occasion of the international competition in 1904 presented, namely, that which was considered the best and some others which deserved notice on account of some details of merit, and if we pay no attention to the means of conveyance (be this by means of a series of wheels, rollers, or sledges on slides), or to the manner in which the tanks are supported and balanced, or to the gates and other details of construction, however much ingenuity they may have displayed, and if we unite into one perfect scheme, which will stand criticism, and is feasible as regards construction, all the best features of the different proposals; if, besides, we leave out of consideration the necessary motive power and the cost of the structure, we shall arrive at the following results as regards the working capacity of an incline of this kind, sketched in Fig. 4 and on which the tanks are conveyed dry:

I. Time spent by a boat in passing over an incline:		
1. Entry of boat, as at Henrichenburg		4′00″
2. Closing of both sets of gates, emptying gap, undoing or inserting water-tight wedges, at the upper and lower tanks, fixing boat in tank		1′30″
3. Starting and stopping* 1′+1′=	2′00″	
The actual trip will occupy with a speed of 0.50 meters along a distance of 40 × 25 = 1,000 meters ∴ 1,000÷0.50=2,000÷60=	33′20″	
		35′20″
4. Fixing tanks in position at canal gates, inserting water-tight wedge, filling gap between tank and canal gates, raising gates, at upper and lower tanks and both at the same time		1′30″
5. Exit of boat		4′00″
Total time		46′20″

Of the total time thus occupied 35′20″ are required for raising and lowerin the tanks and 11′00″ for all other operations. We may remark here that i the case of boats being transported dry some additional time would be required for emptying the tanks before starting from one reach and for refilling them after their arrival at the other reach, to allow the boat to floa out of the tank. We estimate that each operation will take three minute hence the time spent by a boat in passing over an incline will really amount i this case to six minutes more, or 52′20″ altogether.

But in the meantime the boat will have advanced a distance of 100+1,000-100, or 1,200 meters.

II. Interval between two boats following each other. Assuming that whi

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*In order not to produce violent undulations of the water in the tanks and that the may be stopped opposite the canal heads without danger.

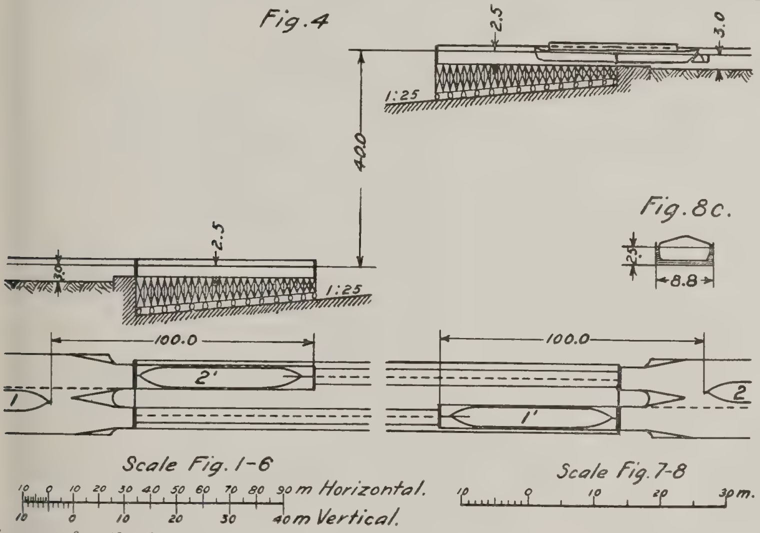
the first boat is leaving the second is entering, this interval will be 46′20″—4′00″, or 42′20″.

III. Two boats crossing each other. Making the same assumptions as in the case of the hydraulic lift, but adding 2×2=four minutes on account of the great distance of 1,000 meters at which the simultaneous operations with respect of movement of boats, moving gates, etc., have to be carried out, the estimated total time will be 46′20″+1′00″=47′20″.

b. Transverse Incline with 1 in 4 Gradient and 40 Meter Fall and a Mean Speed of 0.5 Meter Along the Track. (Fig. 6.)

First. With one tank.

I. Time spent by boat in passing over incline. Making the same assump-



ions as for the items in No. I under letter C and assuming that the boat is onveyed afloat, the amount will be:

$$4'00''+1'30''+1'+1'+\left(\frac{4\times40}{0.5}=5'20''\right)+1'30''+4'00''=18'20''$$

f which 7′20″ are spent on the trip along the incline and 11′00″ in accessory perations.

II. Interval between two boats following each other:

$$18'20''+1'30''+2'+5'20''+1'30''=28'40''$$

III. The crossing of two boats takes:

18′20″+1′00″+4′00″+1′30″+2′00″+5′20″+1′30″+4′00″+1′00″=38′40″

Second. With two tanks.

The loss of time may be estimated in a similar way as under—

I. 4′00″+1′30″+1′00″+5′20″+1′00″+1′30″+4′00″=..... 18′20″
II. 18′20″—4′00″= .... 14′20″
III. 18′20″+1′00″= .... 19′20″

The subjoined table shows the results for falls of from 10 to 100 meters with mean tank speed of 0.50 meter as well as with a mean tank speed of 1 meter the case of a longitudinal incline of 1 in 25. In the latter case, however,

the time allowance for starting and stopping has been doubled and therefore amounts to 2′+2′=four minutes.

We have, besides, investigated the case of a lonitudinal incline of 1 in 10, among various other possible schemes, but with such a steep gradient the downhill ends of the cradles carrying the tanks and the dry pits to be provided at the bottom of the incline to accommodate them would assume ver large proportions.

As shown by the table, the results are especially favorable in the case of transverse incline with two tanks; but, as the same difficulty would be experienced in this case in carrying out all manipulations simultaneously with bot

Table showing working capacities of various inclines

Difference in Level	Longitudinal incline with two tanks						Transverse incline 1 in 4			
	Gradient 1 in 25—				Gradient 1 in 10—		For v=0.5 m.—			
	For v=0.5 m.		For v=1.0 m.		For v=0.5 m.		With one tank		With two tanks	
	Boats follow	Boats cross	Boats follow	Boats cross	Boats follow	Boats cross	Boats follow	Boats cross	Boats follow	Boat cros
	m *s*	*m* *s*	*m* *s*	*m* *s*	*m* *s*	*m* *s*	*m* *s*	*m* *s*	*m* *s*	*m*
10 meters	17 20	22 20	15 10	20 10	12 20	17 20	20 40	30 40	10 20	15
20 meters	25 40	30 40	19 20	24 20	15 40	20 40	23 20	33 20	11 40	16
30 meters	34 00	39 00	23 30	28 30	19 00	24 00	26 00	36 00	13 00	18
40 meters	42 20	47 20	27 40	32 40	22 20	27 20	28 40	38 40	14 20	19
60 meters	59 00	64 00	36 00	41 00	29 00	34 00	34 00	44 00	17 00	22
100 meters	92 20	97 20	52 40	57 40	42 20	47 20	44 40	54 40	22 20	27

tanks as before, an extra delay of 2′+2′=four minutes has been allowed f

In the case of fluctuations in the water levels, further allowances would ha to be made for the time lost in adjusting the levels.

D. REVOLVING LIFTS

A lift of this kind has not yet been carried out, but designs have been p pared for them and one design especially, which secured the second prize the international competition in 1904 and bore the motto "Hapsburg," w worked out in all its details.

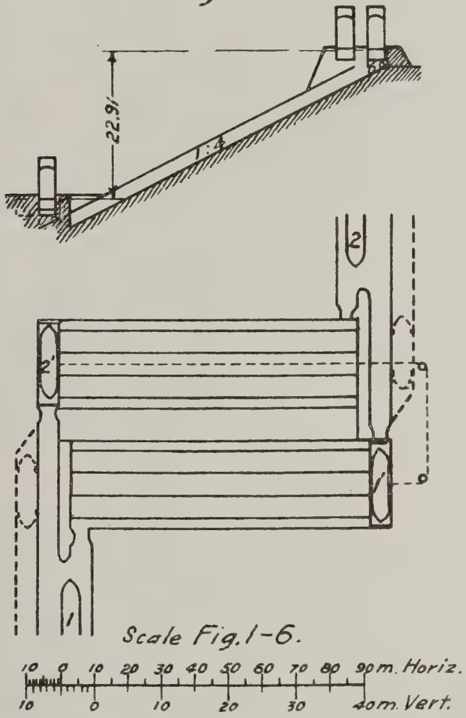
We will assume that lifts of this type can be made to work successfully ev in the case of great fluctuations in the water levels of the adjoining reac and that the troubles arising from an unequal expansion caused by some pa of the structure being exposed to higher temperatures than others, can be s cessfully overcome, as well as those due to wind, etc.; points in respect which the authors of the design which secured the prize are about to prop improvements. We will assume, further, that the rotatory motion of s enormous masses can be regulated at will, and that all the other manipulati as regards the entry and exit of the boats, the handling of the gates, etc., be effected in a manner similar to that with other kinds of appliances raising boats. With these assumptions the corresponding lengths of ti occupied by boats in passing from one pool to the other by means of a

volving lift for two boats and with a 40 meter fall (Fig. 5), etc., may be computed as follows:

I. 4′+1′30″+turning (1′+6′+1′)+1′30″+4′=.......... 19′00″
II. 19′—4′= .... 15′00″
III. 19′+1′= .... 20′00″

In this case, too, an extra allowance of at least two minutes will have to be made, in view of the fact that we have assumed that the various operations at both tanks were to be done simultaneously. The authors of the design which secured the prize have made liberal allowances in this respect by adding to the

Fig. 6.



mounts arrived at by calculation, 6′12″ and 6′30″, respectively, according to he exigencies of the case, and rounding off their figures.

The working capacities of other kinds of appliances for lifting boats could e estimated in a similar way by assuming that such structures could be sucessfully built and would work satisfactorily. This holds good, especially in he case of sundry new designs for locks with saving ponds, although the arious proposals of this kind which were submitted on the occasion of the nternational competition for a scheme of raising and lowering boats at ujezd appeared to be too costly and too complicated, because the authors f some of these designs assumed an absolute want of locking water, although is is a contingency which will never occur on the Danube and Oder Canal; nd moreover, section 1 of the conditions of competition distinctly specified hat an economical working of the canal traffic should be guaranteed by the

proposers of schemes, with the least possible expenditure, but certainly not with no expenditure whatever of water.

The various types of appliances for lifting boats, which we have investigated in sections A to D, and some of which have already been carried out of the sizes assumed herein, and others it would be quite feasible from an engineering point of view to construct, although only at a corresponding higher cost—a point which does not concern us now—present the following features if we compare them with each other in respect of their working capacities.

a. *For Lifting or Lowering a Single Boat*

1. For small falls the ordinary lock, without saving ponds, is the appliance which has the greatest working capacity. The rates at which it was estimated it could be filled and emptied, the gates opened and closed, and the different gears handled, are confirmed by data derived from experience gained with existing structures which have given entire satisfaction in every respect. This working capacity, however, diminishes with very high falls, because it is necessary to avoid the possibility of producing too swift currents in the adjoining canal reaches during locking. An increase in the cross section of the canal would mitigate but not cure this evil.

2. Locks with saving ponds save locking water and they also reduce the forc of the current in the canal reaches; but by multiplying the number of savin ponds the lock becomes more complicated, its working capacity is reduced, an objections arise from an engineering as well as from a traffic-working point o view, if it is a question of adopting them at a specified point of a principa canal with heavy traffic for surmounting high falls exceeding 15 meters Nevertheless, for falls up to about 15 meters they constitute an advantageou method of raising boats, both in respect of working capacity and of satisfactor working.

3. Floating lifts are distinguished by their high working capacity, whic is barely affected by an increase in the rise which has to be surmounted. A low falls, however, the unfavorable influence of the working of the gates an of the great precaution which has to be taken when boats enter or leave th tank, begins to make itself felt. To surmount with their help at a give point very high falls, say any exceeding 25 meters, becomes impracticable i consequence of difficulties in construction.

4. Of inclines for transporting boats by rail only transverse inclines wit gradients as steep as possible need be considered when there is an absolu want of water and the traffic is heavy, although for differences in levels hardly 10 meters—heights which preclude the adoption of inclines on accou of their great cost of construction—their working capacity is not very sati factory, because even with high tank velocities much time is lost, as th various manipulations can not be carried out more expeditiously.

b. *For Lifting One Boat and Lowering Another at the Same Time*

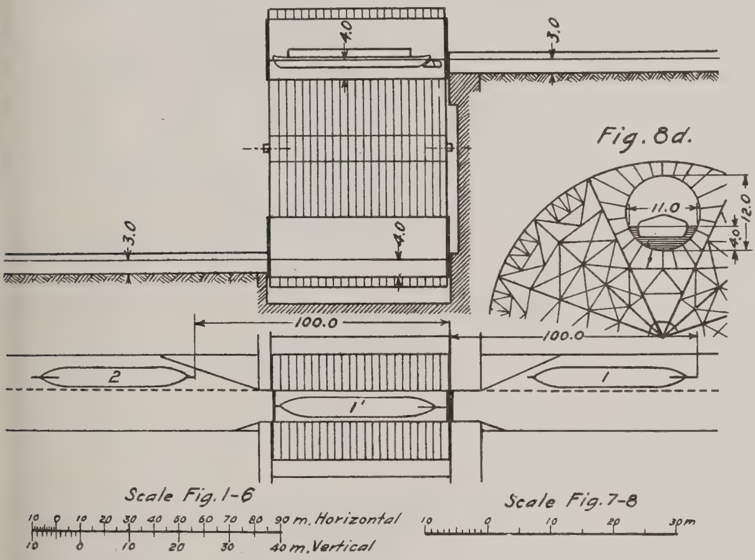
1. Double locks, with average falls of, say, up to 12 meters, are able to co with a heavy traffic on an inland canal, if they are properly managed and wat is abundant.

2. Hydraulic lifts have answered well in practice with boats up to 360 to and are particularly useful when water is scarce and the canal traffic ve heavy, if the difference in level to be surmounted does not exceed, say, meters.

3. Where the difference in level exceeds 30 meters and the whole fall has to be surmounted *in cumulo*, steep transverse inclines with two tanks and revolving lifts, too, will be found useful on account of their high working capacities. The former have already been tried in practice, although only on a modest scale; the latter kind have not yet been tried, but their construction seems to be quite feasible.

4. Longitudinal inclines with two tanks may be adopted when there is an absolute want of water, the traffic is not too brisk, the difference in level is about medium and the slopes of the watershed, which has to be crossed, are not very steep. Their use, however, seems to be limited to falls between 30 and 60 meters for the following reasons. There are technical difficulties in making hem steeper than 1 in 10 for boats of heavy burden; further, both their first ost and working expenses would be too high for falls under 20 meters and with ery high falls their efficiency would be too low, because even with a high tank peed the various manipulations would take up considerable time, to say nothng about the large motive power which would have to be provided for a high peed.

Fig. 5.



The subjoined table shows the theoretical working capacities of the various ocks, lifts, and inclines, hitherto dealt with, for various falls and also their robable effective capacities in actual working.

It has been assumed that the traffic is heavy and the estimates were based on he most unfavorable case to be met with in working, namely, when four boats eet at the lock or lift or incline and three of them are travelling in the ame and one boat in the opposite direction. It was further assumed that intead of their full burden of 600 tons, the boats only carried an average cargo f 375 tons, and that the work was carried on for fifteen hours daily on 250 ays in the year.

Type of lock, lift, or incline[1]	Time spent by boat in changing level	Interval between two boats following each other	Time required for two boats to cross each other	Estimated working capacity			Pro effe capa ton an
				No. of boats per day	No. of boats per year	Tons	
A. *One chamber or tank:*							
1. Lock with 5 m. fall	9′	12′	20′	82	20,500	7,687,500	5,
2. Lock with 10 m. fall with saving ponds	13′	20′	28′	53	13,250	4,968,750	3,
3. Floating lift with 20 m. rise	14′	20′	30′	51	12,750	4,781,250	3,
4. Transverse incline with 1:4 gradient, 40 m. fall and $v=$ 0.50 m	18′20″	28′40″	38′40″	37	9,250	3,468,750	2,
B. *Two chambers or tanks*[2]							
5. Double lock with 5 m. fall	10′	7′	11′	144	36,000	13,500,000	10,
6. Double lock with 10 m. fall	12′	9′	13′	116	29,000	10,875,000	8
7. Hydraulic lift with 20 m. rise	14′	10′	15′	103	25,750	9,656,250	7
8. Transverse incline 1:4, 40 m. fall, $v=$ 0.50 m	18′20″	14′20″	19′20″	75	18,750	7,031,250	5
9. Longitudinal incline, 1:25, 40 m. fall, $v=0.50$ m	46′20″	42′20″	47′20″	27	6,750	2,531,250	1
10. Longitudinal incline, 1:25, 40 m. fall, $v=1$ m	31′40″	27′40″	32′40″	41	10,250	3,843,750	2
(Longitudinal incline, 1:25 40 m. fall, $v=3$ m.)[3]	(21′)	(17′)	(22′)	(64)	(16,000)	(6,000,000)	(4
11. Revolving lift with 40 m. rise	19′	15′	20′	72	18,000	6,750,000	5

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[1] Boats are supposed to be conveyed *afloat* in the tank in every case, which method requires

[2] No allowance has been made for any delay caused by boats not entering or leaving the
tanks at exactly the same moment.

Nor has any allowance been made for the time lost in adjusting the water level between
and tank, when the former differs from the normal.

[3] The speed being excessive, it is unlikely that it will ever be attempted in practice.

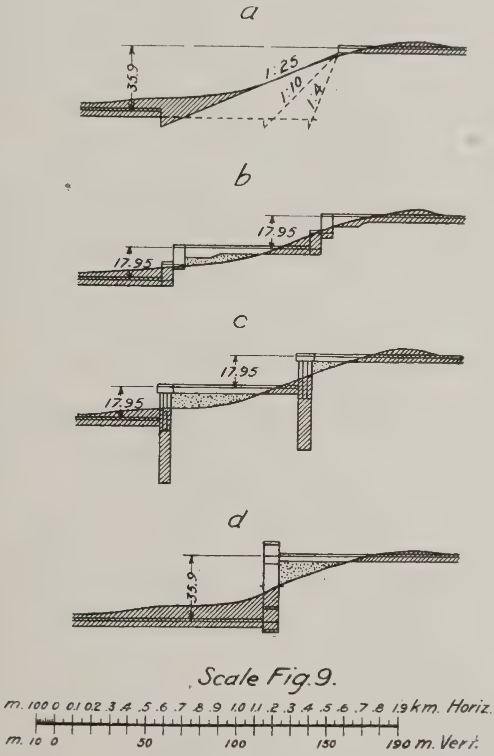
The next step will be to show by a particularly instructive example, namely, the proposed

DANUBE AND ODER CANAL

how much the question of locks, lifts, and inclines may affect the selection of the route for a canal (Figs. 10a to e).

The purpose for which this canal is to be made will be to connect the Danube at Vienna, at 160 meters above datum line, with the Oder at Mährisch-Ostrau at 200 meters above same datum. The length varies between 265 and

Fig. 9



5.5 kilometers in the various schemes, and the level of the summit-reach etween 284.1 and 260.0 meters above datum; hence the total height to be urmounted varies between 200.7 and 152.5 meters, if, provisionally, we conder the port of M.-Ostrau as one of the termini of the canal, which is situated a level of 207.5 above datum.

Fig. 10a shows scheme with locks, which was proposed in 1873. The height the lost fall, the great number of locks (84) and the very short reaches (in any cases only 500 meters long) between locks, evidently militated against the heme being carried out, which was consequently abandoned. We do not opose to say anything more about it.

Another scheme proposed in 1894,* and shown in Fig. 10b, consisted entirely of inclines, the object aimed at being to make the reaches as long as possible for trains of boats. This scheme, however, could not be carried out, because it was found afterwards that the selected method of lifting boats wa not feasible.

The scheme included, like all the others, an entrance lock, which was founc necessary at the commencement of the canal in order to allow boats to pas from the Danube with changeable water level to the canal with almost constan water level and vice versa.

Fig. 10c represents a recent scheme which comprised a series of locks, eac with 5 meters fall; Fig. 10d shows a combination of locks and inclines an Fig. 10e a scheme with locks, with about 10 meters fall with saving pond The dotted lines represent an alternative route with a summit level as low a 260 meters above datum, but this would involve the construction of a tunne 3,050 meters long at the summit and a deep cutting on the side toward th Oder.

To our knowledge, no scheme has as yet been prepared with vertical lifts fc this canal.

The summit-reach is to have a length of 26 kilometers in one scheme and or of 75.75 kilometers in another; and one of even 6 kilometers only in a thi alternative. To provide the requisite quantity of water, the drainage area (the river Becva is to be utilized, the extent of which is 972 square kilometer If required, other drainage areas could be included, without any necessity f pumping, not even if the summit level were fixed at 284.1 above datum. The are many valleys in this region in which from four to thirteen million cub meters of water could be impounded by dams and stored to be used for feedi the summit level, when, owing to long droughts, the water for the canal cou not be taken direct from the river. Even a portion of the available draina area would completely suffice to make good the constant water losses, whi are wholly independent of the types of locks, etc., to be selected, not only the summit reach, but also for a considerable length of the canal, and at t same time to supply the necessary locking water, if required. With a traf of four million tons per annum, locks with 10 meters fall each, with savi ponds, or simple locks with 5 meters fall—assuming that one quarter of t lockings were double lockings and that the boats carried a mean cargo of, sa about 375 tons—would require fifty million cubic meters of water in rou figures for locking; the provision of this quantity would entail an expenditu of from twenty to thirty million Austrian crowns (£833,333 to £1,250,000) extra works, which sum would have to be added to the cost of a canal w locks. The fact should, however, not be forgotten that the whole populat of Moravia, who live in plains, which are unfortunately too often visited floods, would be glad to see as many valleys closed by dams as possible, so to be protected against damages from floods and at the same time to esc the inconveniences of abnormally low water-levels in the rivers. The mo spent in impounding the water would therefore confer an immense bene which can not very well be expressed in figures, upon agriculture, and wo at the same time cheapen the maintenance of the banks of rivers and th

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*The figures in brackets refer to an old scheme, those without brackets to some provements introduced recently.

Fig. 10a.

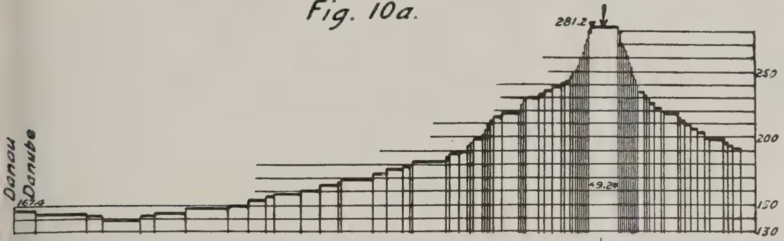


Fig. 10b.

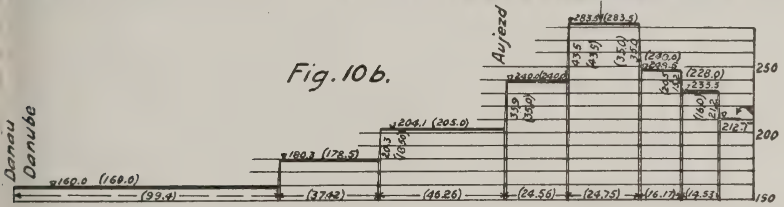


Fig. 10c.

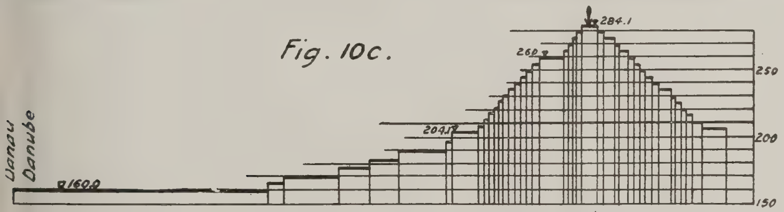


Fig. 10d.

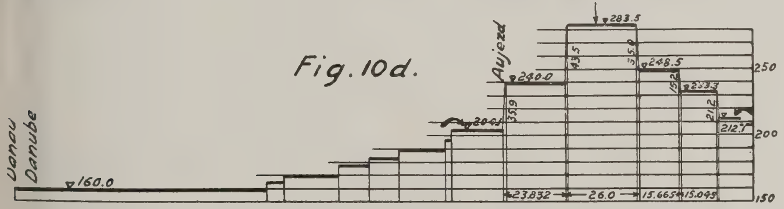
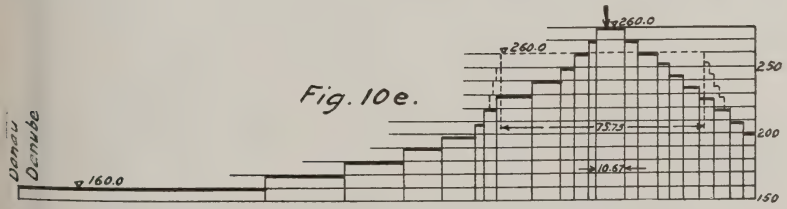
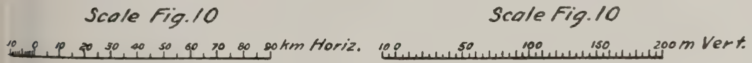


Fig. 10e.



Scale Fig.10 Scale Fig.10



tributaries. A vast amount of hydraulic power would, besides, be stored up, the value of which would also have to be credited to the account of the impounding reservoirs.

The author of a canal scheme for connecting the Danube with the Oder has therefore a free hand in the choice of his means for overcoming changes in the levels and will be able to select such types as will suit best the ground traversed by the canal and at the same time be superior to all other kinds in respect of the safety of the traffic, their working capacity and economy. This choice can be made more easily, more surely, nowadays, after the results obtained in the international competition last year, if the question as to by what means the differences in levels should be surmounted is settled by taking into consideration the whole length of the canal, and by calculating the costs of providing the necessary quantity of water for the canal, not on the assumption that the water would have to be raised from the lower to the upper pools, but that it would have to be provided, as usual, at the level of the summit reach, and thence be distributed cost-free by gravitation down both sides of the summit from reach to reach.

It is seldom possible to prepare, for a point selected beforehand along a canal, any schemes with various types of locks, lifts, or inclines in a rational manner, which could serve any useful purpose when compared in respect of the results that may be attained by them, with a view of selecting the most suitable type and then extend their application to the whole length of the canal. Thus the Figs. 10*a* to *d* show that for the given longitudinal section the only solution, which does not involve any heavy earthworks, is a longitudinal incline with 1 in 25 gradient, although it would be difficult to find such an alignment for the Danube and Oder Canal, except by diverting the center line from existing industrial centers. But the configuration of the slope of the ground, considered in reference to its whole length, is not suitable for the adoption of this kind of installation for raising boats; the trial section made for this purpose and shown in Fig. 10*d* proves, on comparison with Fig. 10*b* and if studied in respect of details, that in respect of the lower portions such is the case.

On the Danube and Oder Canal a particularly brisk and heavy traffic is expected; it is estimated that there will be at least four million tons per annum. Our investigations show, in a sufficiently clear manner, which are the kinds of appliances that would be able to deal with absolute certainty with such a large volume of traffic.

What is, with respect to the future prosperity of the Danube and Oder Canal, the importance which is to be ascribed to the system of boat-lifting appliances and to the number of these structures, as they appear in the various schemes?

The local traffic is scarcely affected by the greater or less number of changes in the level. All that is required is that the boatman should not lose too much time while waiting for his boat to get through the lock, and that the route of the canal should not be located along distant and abrupt hills. Locks, etc. with average falls will answer best in this case.

The long-distance traffic, on the other hand, requires that the number of changes in the levels should be reduced as much, and the canal reaches be made

as long, as possible. To cover the distance between Vienna and the port of M.-Ostrau on a canal 270 kilometers long and at a speed of 4 kilometers per hour, a boat will take 67½ hours plus all the delays at the changes in the levels. In the most unfavorable case, namely, when boats cross, the time thus lost can be calculated as under, in accordance with the investigations previously given, but making allowance for the distance covered by the boat on its way through the lock, lift, or over the incline:

According to Fig. 10c for forty locks of 5 meters fall—

$$40\times(9'+1')-40\times200\ \text{meters}\times\frac{60}{4000}=280'=4\ \text{hours}\ 40\ \text{minutes.}$$

According to Fig. 10e for twenty locks of 10 meters fall with saving ponds and pits—

$$20\times(13'+1')-20\times200\ \text{meters}\times\frac{60}{4000}=220'=3\ \text{hours}\ 40\ \text{minutes.}$$

According to Fig. 10b for one lock and seven longitudinal double-track inclines with 1 in 25 gradient and a tank velocity of 1 meter (instead of 0.50 meter), the total length of each incline being $(283.5-160.0+283.5-212.1)\times25=194.9\times25=4{,}872.5$ meters, the loss of time will amount to—

$$7\times(4'+1.5'+2'+2'+1.5'+4'+1')+(9'+1')-(7\times4872.5+200)\times\frac{60}{4000}=28'$$

The whole trip will therefore take 72 hours 10 minutes, 71 hours 10 minutes, and 67 hours 58 minutes, respectively. This last figure therefore argues in favor of longitudinal inclines with accelerated speed. But in any case the boat would only be able to save the difference of 3 or 4 hours, if she had not to wait at the inclines before proceeding on her voyage.

The influence, which appliances for lifting boats and the greater and shorter lengths of reaches, resulting therefrom, may have upon the formation of trains of boats.

The subjoined table shows the results arrived at on this question. The figures are derived from our investigations as hereinbefore given for different numbers of boats. The tug-boat has not been taken into account in any case, because it is assumed that the towing is to be done by an electric locomotive running along the tow path. An allowance of 2 minutes per boat forming part of the train has been made to cover the time lost in remarshaling the boats at each change of level.

	Interval between trains of boats —									
	When they follow each other					When they cross				
Number of boats	1	2	3		5	1	2	3	4	5
	m s	m	m	m	m	m s	m	m	m	m
Lock with 5 m. fall	12 00	28	42	56	70	20 00	44	66	88	110
Lock with 10 m. fall	20 00	44	66	88	110	28 00	60	90	110	150
Double lock 5 m. fall	7 00	18	27	36	45	11 00	26	39	52	65
Double lock with 10 m. fall	9 00	22	33	44	55	13 00	30	45	60	75
Floating lift with 20 m. rise	20 00	44	66	88	11 0	30 00	64	96	128	160
Hydraulic lift with 20 m. rise	10 00	24	36	48	60	15 00	34	51	68	85
Double-track longitudinal incline with 40 m. rise:										
(*a*) for $v=0.5$ meter-seconds	42 20	89	133	177	222	47 20	99	148	197	247
(*b*) for $v=1.0$ meter-seconds	27 40	59	89	119	148	32 40	69	104	139	173

This table shows that the advantage gained by long reaches is greatly reduced by the delay of individual boats forming part of a train at the change in levels, and that it becomes absolutely illusory in the case of longitudina inclines worked with a tank velocity of 0.5 meter-seconds. Thus, in the latte case a train consisting of five boats crossing another such train at each chang of levels would require for the trip from Vienna to M.-Ostrau by the rout shown in Fig. 10b: 67 hours 30 minutes + 23 hours 5 minutes = 90 hours 3 minutes; whereas, single boats would take by the route shown in Fig. 10e no more than 67 hours 30 minutes + 3 hours 40 minutes, or 70 hours 10 minute A boat, arrived at the Aujezd lift at 204.1 meters above datum, would reac the commencement of the summit reach, at a distance of 23.832 kilometers i 7½ hours; with the same speed, a train of boats would arrive into this reach i 14 hours and more! This being the case, where is the advantage which nav gation is supposed to gain by it? Are the working expenses and towage rate for trains of boats less than for single boats with a well-organized towin service and shorter canal reaches?

The cost of construction of all the locks or locks and inclines, respectivel may be estimated as under:

For the scheme in Fig. 10c with locks of 5 meters fall, the total cost woul amount to either for 40 single locks at 450,000 Austrian crowns, 18,000,00 crowns; or, for the same number of double locks at 760,000 crowns, 30,400,00 crowns.

For the scheme in Fig. 10e, with locks of 10 meters fall, either 20 simp

locks with saving ponds, at 600,000 crowns, 12,000,000 crowns; or 20 double locks at 900,000 crowns, 18,000,000 crowns.

For the alternative scheme in Fig. 10b with seven double-track longitudinal inclines and a double lock of 5 meters fall at M.-Ostrau, in accordance with data derived from the proposals submitted in last year's international competition—

Seven inclines at an average of only 4,000,000 crowns each..	28,000,000
One double lock of 5 meters fall..........................	450,000
Total cost (about £1,185,416).........................	28,450,000

Although a scheme like that shown in Fig. 10d which comprises locks from Vienna to Prerau, and from M.-Ostrau toward the Oder, and canal inclines between these two portions, would involve the construction of dams of relatively small importance in the basin of the Becva, it would on the other hand necessitate pumping water from the Oder on one side and from the river March on the other for working the locks this side of Prerau and beyond Ostrau, respectively. As, however, both these rivers have a very small flow during the low-water season, as proved especially by the experience gained in 1904, no water could be abstracted from them without doing serious injury to agriculture, industry, and the towns situated along their banks. It would, therefore, be inevitably necessary to provide storage reservoirs in the upper portions of the March and Oder basins for feeding these two rivers, in order to have always sufficient water in them to be able to spare a portion of it for the canal. This would be a more roundabout process and the regulation of the supply would also be more difficult than in the case of the reservoirs in the Becva Basin, the supply from which could be more easily regulated and which, in case of necessity, could be enlarged at a relatively small cost.

The working expenses are of still greater importance than the costs of construction, when deciding the question whether locks or inclines are most suitable for the Danube and Oder Canal.

These expenses are about the same for locks of different falls; it is for this reason that one must endeavor to reduce their number as much as possible so long as their working capacity is not reduced below a certain permissible minimum. There is very little difference in the quantity of locking water required for ordinary locks with 5 meters fall, or for well-managed locks with saving ponds and 10 meters fall, and even double locks with 10 meters fall with a saving of 43 per cent per annum only require an extra quantity of water, which is but slightly more than that required for an ordinary lock without saving ponds and with only half the fall.

For other kinds of mechanical appliances for raising boats, where there is no cheap hydraulic power available for lifting and lowering boats and where, at the site of every work of this kind, and more especially in the case of inclines it is necessary to provide a large installation of motive power, the working expenses are several times as high as those for a corresponding number of locks with saving ponds.

The costs of maintenance and annual payments to sinking fund reach a considerable sum, especially if the canal has been constructed for some time and has not yet been opened for traffic, and if subsequently the traffic does not attain a volume sufficiently large in proportion to the money spent upon the

works. The massive locks in masonry, which include very much fewer exposed parts which could be damaged by rust, etc., seem therefore to be always more preferable than mechanical appliances in general, and several special types of boat-lifting appliances in particular.

All the calculations and estimates hitherto made, of which we have produced only a small portion, as well as the question of new legislative measures in the interest of the agriculture of Moravia, induce us to hope that the Danube and Oder Canal will be one with locks with as few reaches as possible.

FINAL CONCLUSIONS

1. Locks, lifts, and inclines along the same canal must be all of as uniform working capacity as possible, if the working of the canal traffic is to proceed smoothly.

2. The question as to by what means boats are to be raised and lowered a changes in the levels of a canal, can only be settled by a comparative study in reference to the whole length of the canal and not merely in reference to a single fixed point along its route. It must be approached from three points o view, namely, volume of traffic, method of working, and total amount of costs

3. Locks will be able to cope with the expected volume of traffic, and they are and will remain the most advantageous, the most certain, the most effective the least costly and most economically worked means of surmounting even a height of certain magnitude along the route of the canal, inasmuch as th water for feeding the canal could be provided at the summit without considerable expenditure.

4. In case of a deficiency of water hydraulic lifts would be means as efficien as locks in respect of working capacity.

ANTONIN SMRCEK.

Brünn, March 22, 1904.

The New German Pontons*

The pontons of the new military bridge equipage of the Germa army are now classed as "whole" pontons and "half" pontons.

They are made of galvanized steel. The "whole" pontons ar rounded off at the stern and have a poop at the bow end 0.25 m (0.72′) high and 1.5 m. (4.2′) long, tapering to nothing toward th stern. They are 8 m. (26.2′) long over all, 1.5 m. (4.2′) broad with a freeboard of 0.85 m. (2.7′). The weight is about 500 k. (1,102 lbs.). The half pontons are each 4.50 m. (14.7′) long, 1.4 m (4.5′) broad, with a freeboard of 0.85 m. (2.7′). The weight of bow end is 300 k. g. (661 lbs.) and of a stern end, 310 k. g. (66 lbs.). The buoyancy of the two half pontons put together is th same as that of the "whole" ponton.

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*Reprinted from The Royal Engineers Journal.

Book Reviews

THE ATLANTIC MARITIME PORTS OF NORTH AMERICA. By Baron Quinette de Rochemont and H. Vétillart. (French.) Published by Ch. Dumod, 49 Quai de Grands-Augustins, Paris. Price, $14.00.

It is a rather remarkable commentary upon us Americans that the first exhaustive treatise on the ports of this country should come from the pens of Frenchmen. The above-mentioned title covers three large volumes and a set of plates in a separate folder.

Volume I deals with the Canadian ports, volumes II and III with the ports of the United States.

Volume II describes the political and administrative institutions of the United States. The division of sovereign authority between the States and the United States is described, the Federal Government and the division of powers between the executive, legislative, and judicial branches. It then discusses the State governments and the similar division of authority in the States. It goes into the question of the local, or municipal, governments, and discusses the subjects of corporations and finances in the States.

The subject of navigation is taken up as covered by the English common law; the modifications introduced therein by statutes, both of the States and of the United States. It explains the public right of navigation in the United States, and the private rights upon navigable waters and their branches. The condition of navigation and of navigable waters under the United States is discussed under the subheads of the authority of the United States over navigation in general, the navigable waters of the United States, the improvement and maintenance of navigable waters of the United States; the regulation, police, taxes, and dues in navigable waters and ports, and the aids to navigation. The condition of navigation and of navigable waters under the authority of the States is discussed under the following heads: The authority of the States over navigation; the powers pertaining to the State governments, and the navigable waters and ports under the authority of the State governments.

Under this last heading are discussed the various methods of administration in the ports of the United States, giving as illustrations certain examples of the principal types of organization and administration in American ports.

Volume III describes the various Atlantic ports in detail, and includes the following ports: Portland, Me.; Sandy Bay harbor of refuge; Boston, New York, Philadelphia, Baltimore, Newport News, Norfolk, Portsmouth, Charleston, and Savannah. Each of these ports is discussed under the following subheads: its geographic and hydrographic situation; its commercial importance; the administration of the port, showing what powers are handled by the State and what by the United States, and giving the organization and duties of the various port boards, commissions, and officials; the subject of pilotage and of quarantine; the various harbor improvements of the port; a description of the port and what facilities, such as wharves, docks, railroads, etc., obtain. The

dues, taxes, and various expenses are explained, whether coming under the State or under the United States.

The charts that accompany the book have been prepared with the characteristic detail of French publications, and show the location and dimensions of the various wharves and piers, both as to plan and elevation, the railroad facilities, and the means of approach by land. Many of the ports' conveniences are shown: for instance, in New York Harbor the ferries of the Pennsylvania Railroad are shown in detail, both as to boats and ferry slips. Many private dry-docks, coal-handling plants, and private derricks of large size are shown in sufficient detail to give a very intelligent idea of the facilities of the port. Much the same detail is followed in the charts of the various ports described, the amount of such detail depending upon the importance of the port. The harbor improvements are shown in considerable detail, and many of these improvements are illustrated by charts which show the successive stages of the improvements from their origin to the present date.—W. D. C.

MILITARY TOPOGRAPHY. By Capt. C. O. Sherrill, Corps of Engineers, U. S. Army. 356 pp.; 154 figures; 1 detached map. Published by George Banta Publishing Co. Price, $2.50.

This book is in clear type and good binding. The author, in his treatment of the subject, has divided it into three parts, viz: Map Reading, Military Topographical Surveying, and Military Sketching.

Part I introduces the student to maps, explaining and illustrating simply the various features found therein. His explanation of scale making, though plain, might be further simplified. The most valuable portion of Chapter II illustrates the various contour forms by drawings. Chapter III explains briefly, though sufficiently, the subjects of directions on maps and the conventional signs. Chapter IV treats of visibility and the intervisibility of points.

Future revisions will probably find the entire Part I more clearly and concisely written and considerably simplified.

Part II treats of Military Topographical Surveying in eleven chapters. The subjects covered include the description, use, and adjustments of the instruments, the reasons for the adoption of the scales used in map making, the various methods of making maps and surveys, the instruments used in finishing maps and the methods of their use, map reproduction, descriptions of the Weldon and the Penta Prism Range Finders, the application of the slide rule to the solution of visibility problems.

Part III treats in a very gratifying manner the subject of Military Sketching, which it covers in six chapters. The entire part is written in a style which is well adapted to the purpose in view. Chapter III, Part III, is probably the most valuable portion of the book. In it the author carries the student step by step through the entire process of making sketches. Any officer or non-commissioned officer of the usual intelligence, having followed the execution of the problem illustrated, should understand the practical procedure in sketching.

Chapter V indicates the data required in the topographical report as distinguished from that on the sketch. The last chapter outlines in fifteen different practical exercises a scheme for self instruction adapted to any locality. At the end of the book are three tables (stadia, logarithms of numbers, and

natural sines and cosines) followed by a good index, which is, however, inaccurate in places.

This being a first edition, naturally, several improvements might be made. The principal value of the volume consists in the detailed explanations, but sufficient care has not been shown in preparing and arranging the plates and figures, and in proofreading.

The author is entitled to the credit of having given to the military profession a simple text which can be studied without the aid of an instructor—a valuable feature when we consider the large number of officers who are anxious to learn this most important branch of military training, but who have not the advantage of an instructor expert in military topography.—C.W.O.

Trade Publications

A very attractive pamphlet is issued by the A. Leschen & Sons Rope Company, illustrating the international ærial wire-rope tramway across the Rio Grande from Coahuila, Mexico, to a point in Texas. The object of the tramway is to carry zinc ore across the Rio Grande River, whence it is hauled in wagons by traction engines to Marathon, on the Southern Pacific Railway. The pamphlet is extremely well illustrated, and the pictures are so clear that they contain valuable suggestions to persons contemplating that kind of a tructure.

The same firm has also just issued a pamphlet describing the various classes f wire rope manufactured by them, showing the details of construction of ach, explaining the special use for which the various kinds of rope are best dapted and the method of keeping them in good condition.

The Diamond Expansion Bolt Company, of New York City, has recently issued a very complete pamphlet showing the various kinds of bolts and other pecialties for wall connections, and the drills for use in placing the same. They emphasize their new Diamond N product, both bolts and drills, and emphasize the following improvements over the old style expansion bolts. The ew shield has clamping lugs which insure positive attachment between the two des and are a considerable improvement over the wires or springs heretofore sed; the holding power of the bolt is materially increased by its corrugated rface, and the shield is prevented from turning in the wall by the longi-dinal ribs on its outer portion.

The Milwaukee Concrete Mixer and Machinery Company's new catalogue lustrates very fully the spherical mixer of that Company, showing the mixer various positions and through various sections. The illustrations are clear d the explanations full, and show the setting of the mixer on many classes of ork.

The Lufkin Rule Company have just issued a small pamphlet on their meas-ing tapes and rules, giving full details in regard to different types, makes,

and prices. Their use of the term ''rule'' covers all sorts of scales, gauges, and measuring sticks for various technical purposes.

The Municipal Engineering and Contracting Company of the Railway Exchange Building, Chicago, Ill., has just issued a very complete catalogue explaining the principles upon which is based their Chicago Improved Cube Concrete Mixer. The machine is described and illustrated in detail, and its particular points are well brought out. The illustrations show the mixer in its various positions and show the action of the concrete during mixing. The catalogue shows the arrangement of one battery of four of these machines now being used on the Panama Canal. There are several tables containing useful information in regard to concrete and its ingredients at the end of the catalogue.

The F. C. Austin Drainage Excavator Company of the Railway Exchange Building, Chicago, Ill., have issued Catalogue 2, Series D, to illustrate the work done by the Austin drainage machines. The catalogue is full of excellent illustrations, showing the various types of work that can be done by these machines, with diagrams of the machines.

The catalogue shows trench machines, as well as the ordinary drainage ditch machines, and illustrates the method of working and the details of all machines. The catalogue is gotten up in very good shape, and it contains considerable matter of interest to anyone who is interested in the subject of excavation by machinery.

SELECTED ARTICLES OF ENGINEERING INTEREST

Compiled by Henry E. Haferkorn, Librarian, Engineer School.

In the lists of selected articles published, the publication is referred to by the number preceding its title in the following list. The following abbreviations will be used: I, for illustrated; D, for diagrams.

(1) Annales des Ponts et Chaussees.
(2) American Machinist.
(3) Canadian Engineer.
(4) Canadian Society of Engineers. Trans.
(5) Cassier's Magazine.
(6) Cement.
(7) Cement Age.
(8) Cornell Civil Engineer.
(9) Electrical Review (London).
10) Engineer (London).
11) Engineering (London).
12) Engineering-Contracting.
13) Engineering Magazine.
14) Engineering News.
15) Engineering Record.
16) De Ingenieur (Hague, Holland).
17) Journal of American Society of Mechanical Engineers.
18) Journal of Western Society of Engineers.
19) Journal of Franklin Institute.
20) Journal of Royal United Service Institution (London).
21) Proceedings, American Society of Civil Engineers.
22) Proceedings, Engineers' Club of Philadelphia.
23) Municipal Engineering.
24) Municipal Journal and Engineer.
25) Railway Age Gazette.
26) Revue Generale des Chemins de Fer (Paris).
27) Scientific American.
28) Scientific American Supplement.
(29) Transactions, American Society of Civil Engineers.
(30) Professional Memoirs, Corps of Engineers.
(31) Journal of the Royal Artillery (Woolwich, England).
(32) Royal Engineers' Journal (Chatham, England).
(33) Proceedings Brooklyn Engineers' Club.
(34) Concrete.
(35) Bulletin de la Presse et de la Bibliographie militaire (Brussels).
(36) Internationale Revue ueber die gesamten Armeen und Flotten (German and French). (Dresden.)
(37) Revue d'Artillerie (Paris).
(38) Kriegstechnische Zeitschrift (Berlin).
(39) The Contractor.
(40) Cement Era.
(41) Canal Record (Ancon, C. Z.).
(42) Proceedings, Engineers' Society of Western Pennsylvania.
(43) Journal, United States Artillery.
(44) Transactions, Society of Engineers (London).
(45) Journal, Association of Engineering Societies.
(46) United States Naval Institute. Proceedings.
(47) Revue du Genie Militaire (Paris).
(48) La Technique Moderne (Paris).
(49) Electrical World.
(50) Electrical Review (Chicago).
(51) Journal, Military Service Institution.
(52) Barge Canal Bulletin.

BUTMENTS.

Cracking and partial failure of abutments and retaining walls. (14), Oct. 13, 1910. . I.

ERIAL NAVIGATION.

The æroplane in war. (28), Oct. 15, 1910. I.—Air craft in war. (27), Oct. 22, 910. I.

RMY ORGANIZATION.

Considerations sur l'organisation de l'armee Anglaise. (35), Sept. 30, Oct. 15, 1910—eorganization of the Russian army after the war with Japan. (In German), (36), ov., 1910, beiheft 123.

UTOMOBILES, MILITARY.

Armee de campagne et automobiles. (36), Supplement 138, Sept., 1910.—Auto-

mobiles lourds a bascule. Binard automobile. L. Ferrus. (37), Oct., 1910. I.—*See* Balloon guns and projectiles. (10), Sept. 16, 1910. I.—Motor traction in the Austrian army. (Das Kraftfahrwesen in der oesterr.-Ungar. Armee.) (38), No. 9, 1910.—*In:* Military technics in the French maneuvers, 1910. (Kriegstechnisches von den franzoesischen Manoevern. (38), No. 9, 1910. I.

BLASTING.

Precautions for maximum safety and effectiveness in blasting. (14), Sept. 22,'10. D.

BOILERS.

Effect of forced draft on boiler capacity and economy. (15), Oct. 22, 1910.—High and low water alarms for boilers. W. H. Wakeman. (29), Nov. 5, 1910. D.—Sectional portable boiler. (10), Sept. 30, 1910. I.

BREAKWATERS.

Difficult work on the Naos breakwater on the Panama Canal. (15), Nov. 19, 1910.—See: The new naval yard at Simons Town, Cape of Good Hope. (11), Oct. 28, 1910. D. I.

BRICK.

Efflorescence on brick work. A. F. Greaves-Walker. (14), Nov. 10, 1910.

CABLEWAYS.

Kabelbanen bij de Gatun-sluizen van het Panamakanal. (16), Nov. 19, 1910. I.—A rock transporting cableway for the harbor works of Rangoon, Burmah. (14), Dec. 8, 1910. D. I.—See also: The Loch Arklet extension of the Glasgow water supply. (10), Nov. 18, 1910. D. I.

CAISSONS.

Building and sinking the Quebec bridge north caissons. (15), Oct. 15, 1910. D. I.—Caissons for the main piers of the new Quebec bridge. (10), Sept. 2, 1910. I.—The orth caisson of the Quebec bridge. (15), Oct. 1, 1910. D.; see also: Naval Yard at he Cape of Good Hope. (11), Nov. 4, 11, 1910. D. I.

CANALS.

Alterations on the Suez Canal. (15), Oct. 22, 1910.—Contract 23, N. Y. Barge Canal. Heavy earthwork on channel and extensive concrete. Operations in progress on locks ear Rochester, N. Y. (39), Oct. 15, 1910. D. I.—The new Erie Canal. V. C. Preini. (11), Sept. 2, 1910. D. I.; Oct. 14, 1910.—Great concrete work on Tieton Canal. (40), Nov., 1910. I.—Hydraulic fill in the turlock irrigation district canal. Kemkey. (15), Oct. 29, 1910. I.—Lining of the Tieton irrigation canal. (39), Oct. 15, 1910. I.—Ohio State canals: Note. (14), Oct. 20, 1910.—Ship cranes, ounterweights, or locks. Some canal problems. (28), Nov. 5, 1910.—Siphon lock n the N. Y. State Barge Canal at Oswego, N. Y. D. A. Watt. (14), Nov. 17, 1910. D. I.—Siphon spillway on the Champlain Canal. (14), Oct. 13, 1910. D.I.; (15), Oct. 8, 910. D. I.—Special methods used on barge canal. (39), Nov. 15, 1910. I.—The Tieton Canal. (7), Nov., 1910. I.—The Tieton Canal. H. W. Sheley; Discussion. 21), Oct., 1910. D.—War Department asks advice on Atlantic Coast Canal. (27), Oct. 1, 1910.—The U. S, Government and the N. Y. State canals. T. W. Symons. (52), ov., 1910.—Relative advantages of locks, lifts, and inclines. A. Smrcek. (30), Janary-March, 1910.

ARBURETTERS.

Feed control of carburetters. (10), Oct. 21, 1910. D.

AUSEWAYS.

The Galveston Causeways. (15), Oct. 15, 1910. D.

CEMENT.

Behavior of hydraulic compounds in sea-water. H. Burchartz. (10), Oct. 14, 910. I.—The cement mill of the Los Angeles aqueduct. (15), Sept. 17, 1910. I.—machine-driven cement sieve. (14), Sept. 29, 1910. D. I.—Natural and Puzlan cements in the U. S. (7), Nov., 1910.—Portland cement works in Sweden. 0), Oct. 28, 1910. D. I.—Purity of a spring preserved by cement. (7), Nov., 1910.—Puzzolan-Portland cement; a suggestion for an improved hydraulic cement. E. uryee. (14), Dec. 1, 1910. D.—Remarkable substitution of cement for lumber. ote. (7), Nov., 1910.

COAST DEFENSE.

Coast defenses of Italy. (In German.) W. Stavenhagen. (38), No. 9, 1910.—Les

anaux maritimes au service de la defense des cotes. (36), Oct., 1910. Supplement
139.—Effects on coast defence of the naval developments of the last few years. C. R.
Buckle. (31), Nov., 1910. The same, H. T. Hart. (31), Sept., 1910. D.

COFFERDAMS.

Some notes on cofferdam construction on the N. Y. State Barge Canal. (12), Sept. 14,
1910. I; see also: The Naval Yard at the Cape of Good Hope. (11), Nov. 4, 11, 1910.
D. I.

CONCRETE. Plain and Reinforced. (See also: Canals.)

Bending moments in concrete wall columns and fixed beams. (15), Oct. 15, 1910. D.
—Bond-friction resistance in reinforced concrete. W. F. Scott. (21), Oct., 1910. D.—
Bonding successive layers of concrete. (15), Sept. 24, 1910.—Collapse of the reinforced
oncrete Henke Building, Cleveland, Ohio. (14), Dec. 8, 1910. D. I.—Concrete ag-
gregates in the Philippines. (15), Oct. 15, 1910.—Concrete standpipe at Westerly, R. I.
I. M. Wilcox. (40), Oct., 1910. I—Concrete work in winter. (39), Nov. 1, 1910.—
Continuity in reinforced concrete construction. (15), Oct. 15, 1910.—Cost of con-
rete on the Panama Canal locks. (15), Dec. 3, 1910.—Depositing concrete by gravity
n a 7-story building. (15), Oct. 22, 1910. I.—Drilling large holes in concrete. (39),
Oct. 15, 1910.—Early development of reinforced concrete. (15), Oct. 29, 1910.—Effect
f salt water on concrete. (41), Aug. 17, 1910.—Efficient plant on concrete building.
39), Sept. 1, 1910. D. I.—Expansion of metal imbedded in concrete. D. N. Becker.
15), Sept. 24, 1910. D.—Exterior treatment of concrete surfaces. (14), Sept. 15,
910; (15), Sept. 24, 1910.—Forms for concrete. J. D. Stevenson. (42), Oct., 1910.
. I.—Further tests on the effect of electric currents upon concrete and steel. U. J.
icholas. (14), Dec. 1, 1910. D. I.—Handling of concrete during cold weather. J.
I. Chubb. (40), Dec., 1910. D.—Investigations on the slip of rods imbedded in con-
rete. H. Burchartz. (15), Nov. 12, 1910. D.—Large portable plant for crushing
ixing, and placing concrete on Catskill Aqueduct. (12), Dec. 7, 1910. D. I.—
argest concrete oil reservoirs in the world. H. M. Wright. (27), Dec. 10, 1910. I.—
igno-concrete, an early form of reinforced concrete. Thom. Parker. (27), Sept. 10,
910. D.—Metal wall forms for concrete houses. (15), Nov. 19, 1910. D. I.—Method
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ethods of giving concrete a polished, glossy surface. A. A. Houghton. (34), Nov.,
910.—Paints for concrete. E. F. Burchartz. (14), Oct. 27, 1910.—Production of
ncrete pipes by centrifugal action. A. Gradenwitz. (27), Oct. 1, 1910. I.—Rails
r reinforced concrete wharves. (10), Oct. 28, 1910. D.—Reinforced concrete cold
orage warehouse at Jersey City, N. J. A. G. Hoadley. (14), Nov. 3, 1910. D.—
einforced concrete poles. Note. (7), Nov., 1910.—Reinforced concrete sewers in soft
ound, Seattle. (15), Oct. 22, 1910. D. I.—Reinforced concrete trestles for rail-
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parately molded concrete members for a sea wall. (15), Nov. 19, 1910.—Testing
ncrete aggregate. (24), Sept. 14, 1910.—Tests for use of salt in cold weather. G. P.
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10. D. I.—Tests on concrete in sea water. (14), Nov. 3, 1910.—Tests to deter-
ine the effects of frost on concrete and methods of concrete work in freezing weather.
H. Chubb. (12), Nov. 23, 1910. D.—Two concrete stairways. (15), Oct. 22,
10. D. I.—Two reinforced concrete coal pockets. M. S. Falk. (21), Oct., 1910.
I.—Treatment of concrete surfaces. (39), Oct. 15, 1910. Unit system in concrete
awall. (39), Nov. 1, 1910. I.—Unusual concrete details in an English building.
5), Nov. 19, 1910.—Washing sand and gravel for concrete and mortar. (7), Nov.,
10.—What is Concrete? The answer. (34), Nov., 1910.—Complete floating con-
ete plant. L. M. Adams. (30), January-March, 1910.—Effect of fire on concrete
m. Callard. (30), January-March, 1910.

ONDUITS.

Jones Falls covered conduits and boulevard, Baltimore. (15), Dec. 3, 1910. D.

ONSTRUCTION.

Erecting a steel frame shop without a traveller. (15), Sept. 24, 1910. I.

ONTRACTS AND CONTRACTORS.

Changing plans after contract award. D. J. Hauer. (39), Oct. 15, 1910.—Con-

tractor's plants: types, layouts, and methods of operation. F. E. Field. (42), Oct., 1910. D. I.—Notes on recent decisions of the Court of Claims. W. B. King. (15), Dec. 3, 1910.—Standardization of contract forms. R. W. Creuzbaur. (39), Sept. 1, 1910.

COST DATA.

Cost data on the Panama Canal. (14), Nov. 24, 1910. Notes on cost data and cost analysis. D. J. Hauer. (39), Sept. 15, 1910.

COST KEEPING.

Organization and cost keeping on the Los Angeles aqueduct. (15), Oct. 15, 1910.

CRANES, HOISTS.

Cranes at Krupp's Yard, Kiel. (10), Sept. 16, 1910. I.—Special methods used on Barge Canal. (39), Nov. 15, 1910. I.—Steel hoisting towers for concrete. Note. (15), Nov. 19, 1910.

CRIBS.

Placing a floating concrete crib for a light-house. (15), Nov. 19, 1910. I.

DAMS.

An arched dam at Las Vegas, New Mexico. (15), Oct. 8, 1910. D.—Arched masonry dam at Las Vegas, N. M. C. W. Sherman. (14), Oct. 27, 1910. D.—Barren Jack masonry dam in New South Wales. (14), Nov. 17, 1910.—The Beardsley reinforced concrete dam. (15), Nov. 26, 1910. D.—A buttressed masonry dam reinforced with steel I-beams. F. S. Tainter. (14), Nov. 24, 1910. D. I.—Construction of the new Croton Dam. (39), Oct. 1, 1910.—Construction plant and methods for building an 85,000 cubic yard rubble concrete dam. (12), Sept. 21, 1910. D. I.—Construction plant for the Holter Dam. (15), Oct. 29, 1910. D. I.—Design and construction of the St. Andrews movable dam and lock on the Red River at Lockport, Manitoba. E. A. Forward. (14), Oct. 6, 1910. D. I.—Completing the movable dam. (52), Oct., 1910. I.—Discharge measurements and formulas for some large overflow dams. W. F. Martin. (14), Sept. 29, 1910. D. I.—The Green River gravity water supply at Tacoma. St. Sims. (15), Oct. 22, 1910. D.—The La Prele Dam; a 130-ft. hollow reinforced concrete dam near Douglas, Wyo. (14), Nov. 10, 1910. D. I.—Locks and dams of the Panama Canal. (10), Sept. 30; Nov. 4, 11, 25, 1910. D.—Methods of construction and contractor's plant on the Ashokan Reservoir, N. Y. water supply. (24), Oct. 19, 1910. D. I.—Movable dams on the N. Y. State barge canal. (14), Dec. 8, 1910. D. I.—Progress of the Barren Jack dam, New South Wales. (15), Oct. 15, 1910. Progress of the Great Barren Jack dam in Australia. (10), Sept 23, 1910.—Rebuilding lock and dam at Pittsburg. (39), Oct. 1, 1910. D. I.—Repairs to a dam near Crampagna, France. Note. (15), Oct. 22, 1910.—Use of the rolling dam in Europe. (15), Oct. 29, 1910.—Effect of fire on concrete dam. Callard. (30), Jan.-March, 1910.

DERRICKS.

An improved mast step for derricks which permits removal of sheaves without unshipping mast. (12), Sept. 21, 1910. D.

DIVING.

Physics of diving. (28), Oct. 1, 1910. I.

DOCKS.

Clyde Harbor and dock extensions. (10), Sept. 30, 1910. See also: The Naval Yard at the Cape of Good Hope. (11), Nov. 4, 11, 1910. D. I.; (11), Oct. 28, 1910. D. I.

DREDGES AND DREDGING.

A dipper-dredge for a railway embankment. F. N. Smith. (14), Nov. 3, 1910. I.—Hydraulic giant and dredge plants for excavating some 7,800,000 cubic yards on the Pacific division of the Panama Canal. (12), Sept. 28, 1910.—Ladder dredge work on the N. Y. State barge canal. (12), Sept. 21, 1910.—A new skip dumping device for ableways. (12), Nov. 9, 1910. D.

EMBANKMENTS.

Protecting embankments and restoring them when washed out. (14), Nov. 10, 1910.—Protecting railroad embankments against currents. (15), Oct. 29, 1910.—The Victoria mbankment pavement. (15), Oct. 15, 1910.

NGINEERING LITERATURE.

How may an engineer make best use of current engineering literature. (14), Nov. 17,
910.

XCAVATION AND EXCAVATORS. See also, Dredges.

Combination concrete dumping bucket and dump car. (14), Oct. 6, 1910. I.—Exca-
ation methods, Fourth Avenue Subway, Brooklyn. (15), Dec. 3, 1910. D. I.—Large
ydraulic excavation plant. (39), Oct. 15, 1910. D.—Methods of excavating canal
rism, using a bridge conveyor excavator. (12), Nov. 23, 1910. I.—A new grab
ucket for ore and coal handling plants and contractor's use. (14), Sept. 22, 1910. I.
—A new type of grab bucket. (39), Oct. 1, 1910. I.—Trenching for a sewer, using a
rab bucket excavator, with some data on the concrete work. (12), Sept. 28, 1910.
. I.

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Care in thawing explosives. (39), Sept. 1, 1910. I.—Cordite. Chemistry and
anufacture of a remarkable explosive. (28), Sept. 17, 1910.—Some modern develop-
ents in methods of testing explosives. C. E. Munroe. (46), Sept., 1910. I.—Some
emarks on wet gun cotton. R. L. McClintock. (32), Nov., 1910. I.

LOODS.

East Side levee and sanitary district, East St. Louis. (15), Sept. 17, 1910. D.—
orests in relation to climate and floods. (27), Oct. 29, 1910.—A method of flood
rotection. (15), Oct. 22, 1910. I.—Les troupes du genie aux inondations de Paris
n 1910. (47), Aug., Sept., Oct., 1910. D.

OREST FIRES.

How the Government fights forest fires. C. A. Sidman. (27), Sept. 17, 1910. I.

OUNDATIONS.

Construction of the Kinzie street drawbridge, Chicago, and its deep foundations:
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Editorial Notes

With this issue the PROFESSIONAL MEMOIRS enters upon its third year of existence, and has now definitely passed its experimental stage. From this it is not to be inferred that we have accomplished all the results that we desire, and that we intend to remain content with the PROFESSIONAL MEMOIRS as it now appears. This magazine should supply the technical details of our work formerly published in the reports of the Chief of Engineers, but which are no longer permitted therein to the extent that is necessary to give to the engineers employed on our public works the interesting and valuable information that they should possess in regard to the projects, plant, and methods of their fellow workmen in other parts of the country.

In addition to that, the MEMOIRS should be used, for the time being at least, to give short, concise histories of the various important projects now under way, accompanied by such suitable maps hat all the readers of the MEMOIRS may become familiar with the history of the work and the success or failure of the methods used thereon. Our most valuable information comes from experience, and if we can gain that experience vicariously and can model future works in the full light of the success and failure of previous similar works, we are all that much better off. For this reason we hope that the subscribers to the MEMOIRS will narrate not only successes but failures as well, by means of which other readers may benefit.

There is one other function that the MEMOIRS should perform, and that is to select articles of special interest to our readers from oreign publications and from other sources which are not generally vailable, either in private or public libraries, except in the very arge cities. Many of the best and most exhaustive articles are ublished in the proceedings of societies and in magazines having a very limited circulation.

It is proposed in future numbers of the MEMOIRS to republish

certain of these articles, so as to place them at the disposal of our readers. The first of such articles to appear is the one on Locks, Lifts, and Inclines, by Professor Antonin Smrcek of Austria, in which the advantages and disadvantages of these various methods of overcoming differences in level on waterways are discussed in a very thorough manner by a writer whose opinion is entitled to every respect. This article originally appeared in the Proceedings of the Permanent International Association of Navigation Congresses for the meeting held at Milan, Italy, in 1905.

In order to stimulate interest in the Professional Memoirs and to compensate in a small measure the contributors thereto, the Board of Editors has decided to make the following offer to all the Civilian Assistants of the Corps of Engineers, including both engineering and clerical assistants in the offer. One year's free subscription will be given to every such contributor who has published in any volume of the Memoirs an article or articles aggregating not less than five thousand words (twelve pages) upon subjects pertaining to the Public Works under the Corps of Engineers. These articles may be illustrated. At the end of each year an additional prize of twenty-five dollars will be given to the author of the best article published during the year. The award will be made by a board of non-competing assistant engineers, and the name of the successful contributor will be published in a list that will be carried in the Professional Memoirs.

A decision in regard to the eight-hour law was recently made in the Federal Circuit Court, sitting at New Orleans, La. The case was that of the United States *v.* Herman Garbish, and arose out of the alleged violation of the above-mentioned law in connection with a contract for levee work in 1909. The case was dismissed and the defendant discharged by the judge, who said, in part, as follows:

> "The defendant rests his case on the proposition that the building of levees on the Mississippi River, in the Eastern District of Louisiana, at all times presents an extraordinary emergency, and hence that particular work is exempted from the operation of the law. This is denied by the Government, and the indictment contains the general averment that no extraordinary emergency existed. The question thus squarely presented is decisive of the case,

if defendant's contention be sustained. The building of levees in Louisiana has at all times presented many problems. It is absolutely necessary, not only for the preservation of property and to permit the cultivation of the land, but to safeguard the very lives of the inhabitants as well, that levees should be built on the banks of the Mississippi River in this locality; therefore, it has always been usual that levee work proceed with the greatest dispatch and the labor of the day has never been restricted to eight hours. In the nature of things, it is impossible to employ an unlimited number of men or teams in the building of levees, as no matter how great a force a contractor may assemble the work will not permit of crowding. It is necessary that levees be built in as short a time as possible, in order that they may settle as much as they can, and that the grass may become well rooted upon them before they are called upon to bear the strain of a high river. It is true that the months of August, September, October, November and December are the most favorable for levee building, but there is no certainty that during any part of these months the river will maintain a low stage. When the river is bank full, necessarily no levee can be built. Statistics of the river's height at New Orleans show that during the past twenty-five years the river has been bank full on nearly every day of the year, and these statistics may well apply to the locality where the defendant was working. An unprecedented rain, or an early freeze, followed by a thaw, anywhere in the valley of the Mississippi River, or its tributaries, might unexpectedly cause the river to rise at New Orleans. No one can foresee or anticipate the acts of nature, and who can say that a few days more time in which it might have become solidified would not have so materially added to the levee strength as to enable it to withtand the pressure from that which it might signally fail. All of hese facts are within common knowledge of the people of this district, and in connection with the specific allegations of facts in the indictment, overcome the mere conclusions of the pleader that no extraordinary emergency exists. The case presented here is not that of a contractor trying to complete his job on schedule ime, nor is it a question of expediency, or the saving of expense. n my opinion, the building of levees on the banks of the Missisippi River in the Eastern District of Louisiana presents at all imes an extraordinary emergency. It may be that the indictment s otherwise demurrable, but I prefer to base my decision on the road ground above set forth."

The price of the MEMOIRS has been reduced each year and now tands at three dollars, which is a reasonable sum when compared ith other similar publications. We do not expect to decrease the rice further, but hope that, in time, the suggestions of certain of ur readers may be practicable and that we may be able to increase e number of issues to six per annum.

A publication of this class is not an automobile. You can not start it, and then let it run until someone turns off the power. Its success can only be assured by the constant assistance of all those interested in the continuance of the magazine.

In connection with the subject of the improvements of terminal facilities for water-borne traffic, river and harbor engineers will be interested in a portion of the recent address by Mr. Thomas E. Murray, President of the Association of Edison Illuminating Companies, at the last annual meeting of that association. Mr. Murray said in part:

> "It is a common observation in cities located on the water front where there is considerable shipping activity, that provisions for the handling of freight and merchandise are either entirely wanting or they are of a very primitive character. As a striking example, the New York City water front along the North and East rivers may be cited. Here, notwithstanding continued active canvassing and concentrated effort in the direction of stimulating the installation of efficient and economical hoisting and conveying apparatus, the response has been very slow, and far behind the rate of improvement manifested in any other direction of power application. A notable improvement, however, has been manifested within the last year. In European shipping ports, this service is splendidly taken care of by extensive harbor works, which include not only commodious, modern fireproof docks and piers, but adequate provision for cranes, hoists, and conveying apparatus of all kinds, controlled either by a comprehensive compressed-air distribution, or by distributed electric power."

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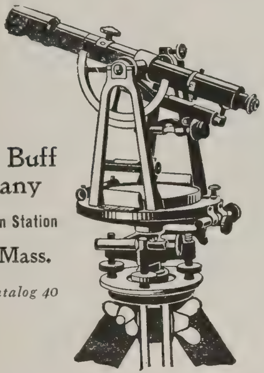

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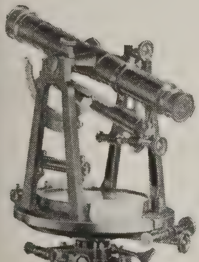

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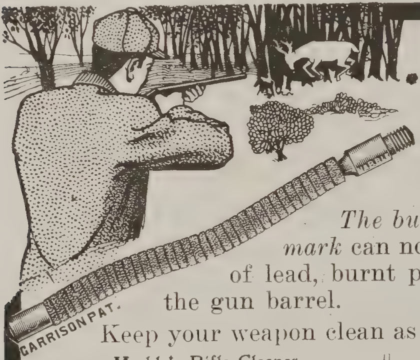

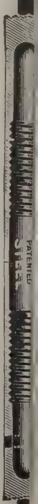

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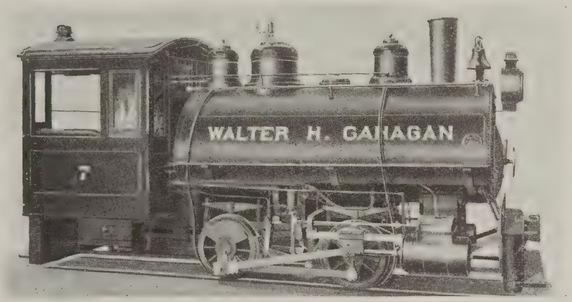

PARTICULAR ATTENTION PAID TO THE DESIGN AND CONSTRUCTION OF LOCOMOTIVES FOR

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It pays us all to have you read this part of the Memoirs

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(LIMITED)
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Telephone and Telegraph Cross-arms and Poles, Lumber, Timber, Ties, Piles, and Paving Blocks

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Cable Address: Creosote, Slidell, La. ABC Code used.

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ROCK EXCAVATION

Rock reduced to fragments small enough to be removed by dipper or bucket dredges. Specially adapted for use in conjunction with dredges, etc. when forming or deepening—

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Canals

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ROCK EXCAVATION

One of the outstanding features of this system is that the lifting of the broken rock is as easy as ordinary hard dredging. When explosives are used the pieces are sometimes large and therefore costly to lift.

WITHOUT EXPLOSIVES

By LOBNITZ PATENT SYSTEM

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Catalogue Mailed on Application

BROWN HOIST LOCOMOTIVE CRANES *AND* CRAB BUCKETS

15-TON 8-wheel *CRANE*

24-FOOT Ore Grab *BUCKET*

This equipment is adapted for handling sand, coal ashes, broken stone, limestone, ashes, etc.

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The Brown Hoisting Machinery Company

Main Office and Works
Cleveland, Ohio

Branch Offices
New York, NY.
Pittsburg, Pa.

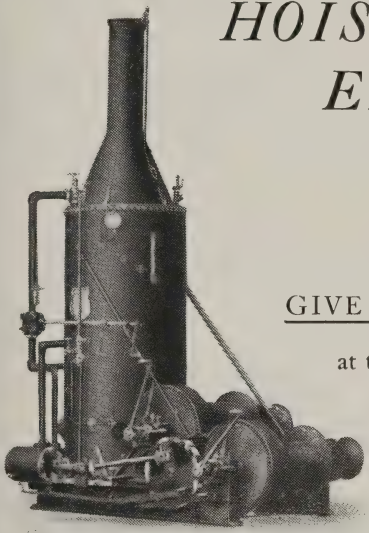
Builders of Hoisting Machinery of all descriptions

"AMERICAN"

HOISTING ENGINES

AND

DERRICKS



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at the lowest cost for operating
and maintaining

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Standard "American" Hoisting Engine

SAFEGUARD YOUR PLANT BY USING

GENUINE "*CROSBY*" CLIPS

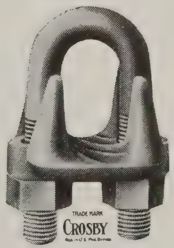
DROP FORGED

CANNOT BREAK

GALVANIZED

CANNOT RUST

Both layers of rope are gripped—*cannot slip.*



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AMERICAN HOIST & DERRICK CO.,

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High Grade Hoisting Engines

Have steel gears and steel detachable ratchets. They have extra heavy shafting, and long bearings with solid end, hand-forged connecting rods.

Drums are bronzed bushed. Frictions are positive.

Ports of steam chest and valve are large, insuring great capacity and high speed.

Boilers have large grate area and heating surface and are securely fastened to the engine bed.

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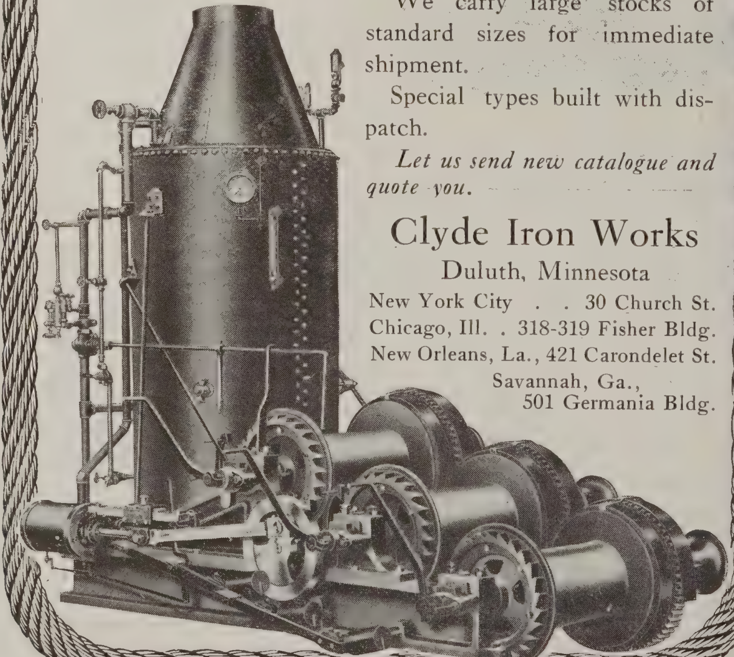

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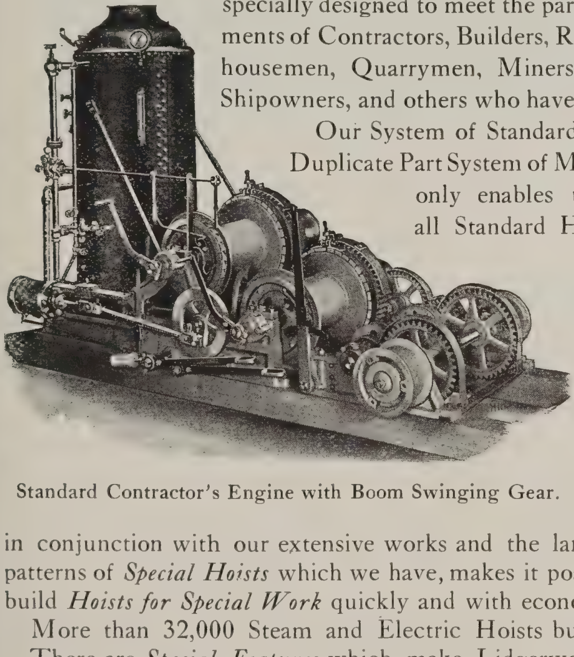
HOISTING ENGINES

The Double Friction Drum Engine with boiler shown in this cut is the most perfect Contractor's Hoist ever made and is adapted to a wider range of work than any other type—BUT we have more than 300 *other styles and sizes* of regular catalogued *Steam and Electric Hoists* from which our customers may choose, every one of them specially designed to meet the particular requirements of Contractors, Builders, Railroads, Warehousemen, Quarrymen, Miners, Lumbermen, Shipowners, and others who have hoisting to do.

Our System of Standardized Parts and Duplicate Part System of Manufacture not only enables us to produce all Standard Hoists with the highest degree of accuracy, quality, and economy, and assures the prompt filling of orders for *Repair Parts which fit*, but in conjunction with our extensive works and the large number of patterns of *Special Hoists* which we have, makes it possible for us to build *Hoists for Special Work* quickly and with economy.



Standard Contractor's Engine with Boom Swinging Gear.

More than 32,000 Steam and Electric Hoists built and in use.

There are *Special Features* which make Lidgerwood Hoists the *Easiest and Handiest to Operate.*

LIDGERWOOD CABLEWAYS

The placing of the order for more than $300,000 worth of Lidgerwood Traveling Tower, Electrically Operated Cableways for the Construction of the *Gatun Locks* of the *Panama Canal* is only one more recognition of their superiority.

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CLEVELAND LONDON, ENG.

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H. Channon Company.

Chicago.

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Revolving Locomotive Cranes
Whirleys
Drag Bucket Excavators
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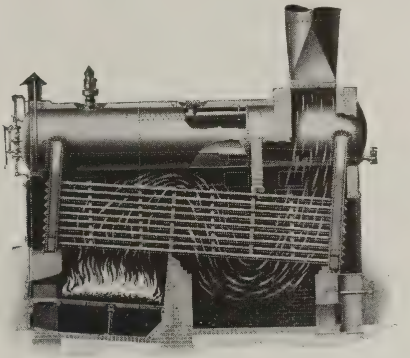
E. KEELER COMPANY
(ESTABLISHED 1865)
WILLIAMSPORT, PENNSYLVANIA



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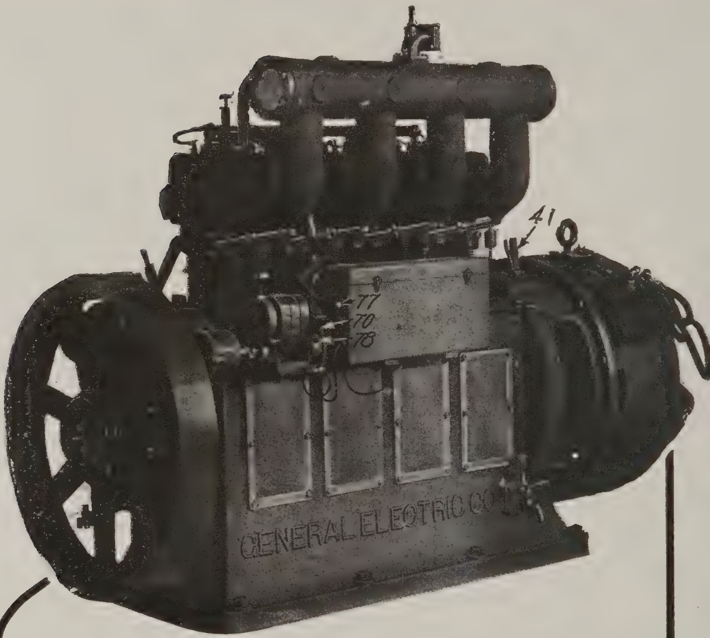

Gasoline Engine Driven Electric Generating Sets

The 25-kilowatt gasoline engine generating set was specially designed for use in the seacoast fortifications. A large number of these sets are now being manufactured by the General Electric Company for the War Department.

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Principal Office
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SCHENECTADY
N. Y.
Sales Offices in
all Large Cities

1977

COST of transportation is one of the important factors to be considered in selecting conduit material. Advantage in this respect is but one of the claims which

ORANGEBURG
FIBRE CONDUIT

has to the attention of engineers. Extreme lightness reduces carriage costs to a minimum.

Breakage from factory to the bottom of the ditch is so slight that it can be almost disregarded. Long lengths and snug-fitting joints make perfect work, even if only ordinary labor is used.

ORANGEBURG FIBRE CONDUIT gives assurance against seepage of concrete and electrolysis. Tough, durable, efficient, it is the perfect conduit material.

And its superiority is proved by repeated tests. Our *Conduit Book*, giving full detailed results of tests, mailed on request.

THE FIBRE CONDUIT COMPANY
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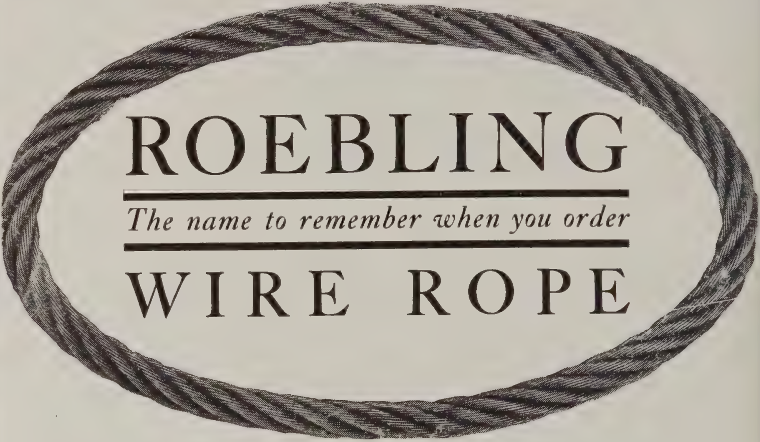

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WIRE ROPE

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magazine and omit to read the advertisements. Look them over, and

IF YOU NEED ANYTHING ADVERTISED HEREIN write to the advertiser and tell him what you want and where you saw his "*ad*"

For Heavy Duty of Every Character

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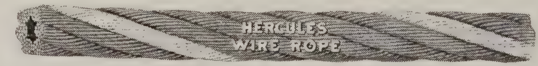

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The adaptability of the HERCULES Wire Rope in its various styles of construction—Patent Flattened Strand and Round Strand—to extra severe service of every nature is recognized by Construction Engineers everywhere.
Derricks, Cableways, Dredges, Steam Shovels, Ballast Unloaders.
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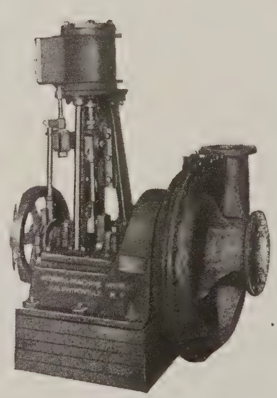

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Stationary and Marine 2–200 Horsepower
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pronounce it the best pump on the market for general contract work, draining cofferdams, trenches and swamps, unwatering mines, or irrigation pumping.

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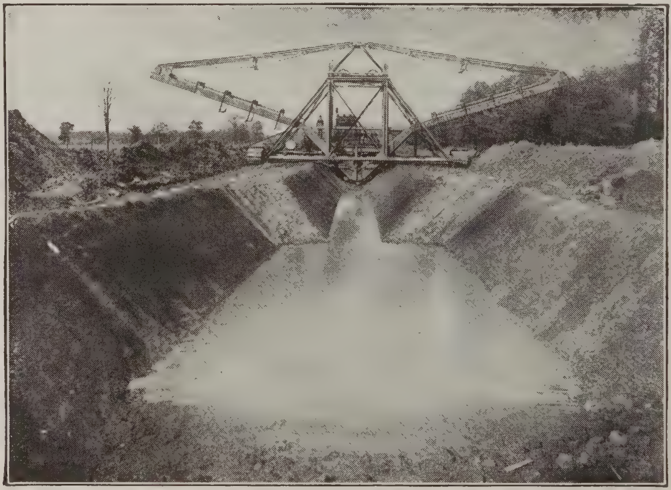
OF USING AUSTIN DRAINAGE AND IRRIGATION EARTHWORK MACHINES

comes from the fact that each is a special machine for doing one thing cheaper and better than any other machine can do it.



Ditch Being Dug With Sloping Banks—An Austin Drainage Excavator Ditch showing variations in width made by same machine

An *Austin Drainage Excavator* digs ditches cheaply because it constructs a ditch to template to the engineer's plans in one operation.

Every Austin Machine for Drainage and Irrigation Earthwork performs one kind of work better than any other machine. This is the principle on which they were designed and are constructed.

WE SELL OUTRIGHT OR LEASE
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OUR FULL LINE COMPRISES:

The Austin Drainage Excavator
The Austin Levee Builder
The Austin Drag Line Excavator
The Austin Side Hill Ditcher
The Austin Highway Ditcher
The Austin Orange Peel Ditcher
The Austin Rolling Platform Traction
The Austin Tile Ditcher
The Austin Stump Puller and Grubber

F. C. Austin Drainage Excavator Company
Railway Exchange *CHICAGO, ILL.*
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RED CROSS LOW FREEZING EXPLOSIVES

Red Cross Ammonia Dynamite for general work.
Red Cross Nitroglycerin Dynamite for work requiring a quick explosive.
Red Cross Semi-Gelatin for wet work.

Low Freezing *Slow Freezing* *Quick Thawing*

INVALUABLE AT ALL TIMES IN THE YEAR

ALL KINDS OF EXPLOSIVES FOR ALL KINDS OF WORK.

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BLASTING SUPPLIES

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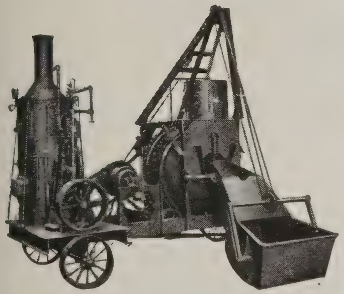
Established 1802 WILMINGTON, DEL., U.S.A.



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Milwaukee Concrete Mixer and Machinery Company
MILWAUKEE, WISCONSIN

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INCORPORATED
UNION TRUST BUILDING
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WITH STEEL, METALLIC, AND LINEN LINES

CARRIED IN STOCK BY ALL LEADING DEALERS

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Sole United States Agents.

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ACCURACY, Durability and Beauty of Design—the three fundamental features by which the worth of

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THE LUFKIN RULE CO.

Saginaw, Mich., U. S. A.
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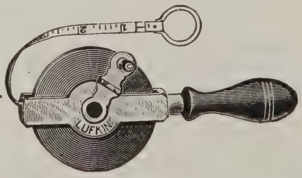

FOSTER VALVES

There are many types of Foster Valves for wide and diversified service—all make for economy—some, in addition, assure safety.

In buying a valve that is not certain, not sure in the performance of its functions, you run big chances of making experience unnecessarily expensive, if not worse.

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Relief Valves, Etc., Etc.

FOSTER ENGINEERING CO.
NEWARK, N. J.

IN THE MANUFACTURE OF

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the "details have been carefully considered, and through nearly half a century of experience and study a perfection of quality has developed that is recognized by users all over the world."

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"MOST supply houses sell them —yours CAN— if they DONT or WONT—tell US"

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Largest Manufacturers of High-Grade Engineering Specialties in the World

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GOLDSCHMIDT PATENTS

WELDING PROCESS

Repairs All Wrought-Iron and Steel Sections In the Quickest and Most Economical Manner

WELDS CAN BE MADE ANYWHERE

THE THERMIT PROCESS offers the great advantage that *welds on large sections can be made without removing the broken part from its position.* Locomotive frames are welded without dismantling the engine; sternposts and rudder frames of steamships are repaired without removing them from the ship. The same advantages apply to other large repairs which may be executed in a few hours.

Thermit is a mixture of finely divided aluminum and iron oxide which, when ignited, reacts to form superheated liquid steel and superheated liquid slag (aluminum oxide) at a temperature of 5,400° F. In welding, the steel is poured into a mold surrounding the pieces to be welded together and which have previously been brought to a red heat by means of a gasolene torch. The very high temperature of the Thermit Steel causes it to dissolve the metal with which it comes in contact and amalgamate with it to form a single homogeneous mass when cool.

We execute repairs by contract under guarantee or supply materials and supervision. Small repairs are made at our Jersey City Shops. Estimates promptly furnished on receipt of a blue print or sketch.

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SAN FRANCISCO

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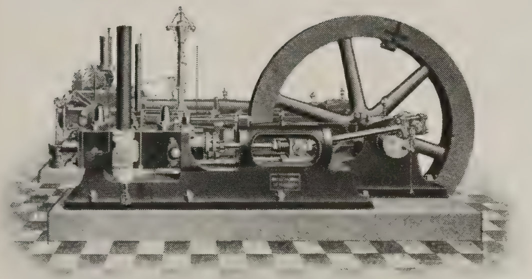
TORONTO, CAN.



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CARBONIC ANHYDRIDE
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FOR MARINE AND LAND INSTALLATIONS

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Builders and Operators of Hydraulic and Clam Shell Dredges

Capacity 2,000,000 cubic yards per month

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Established 1829

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P. SANFORD ROSS, Incorporated

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Sub-Marine Rock Removal

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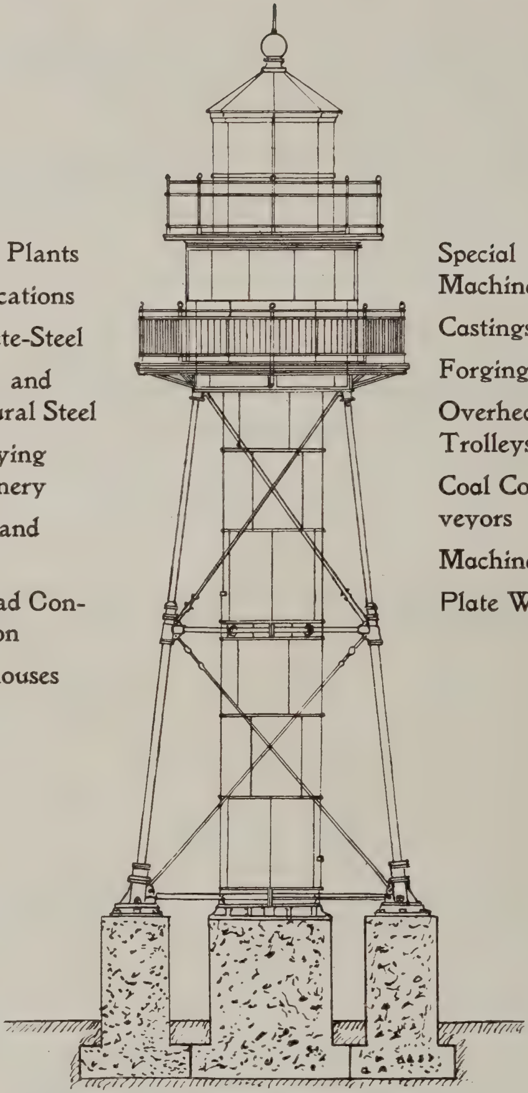

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Contracting, Constructing, Manufacturing Engineers

We Build HYDRAULIC DREDGES
to handle Material (except Solid Rock),
in Any Quantity, from Any Depth, to
Any Distance, to Any Height

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Builders of

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OF THE

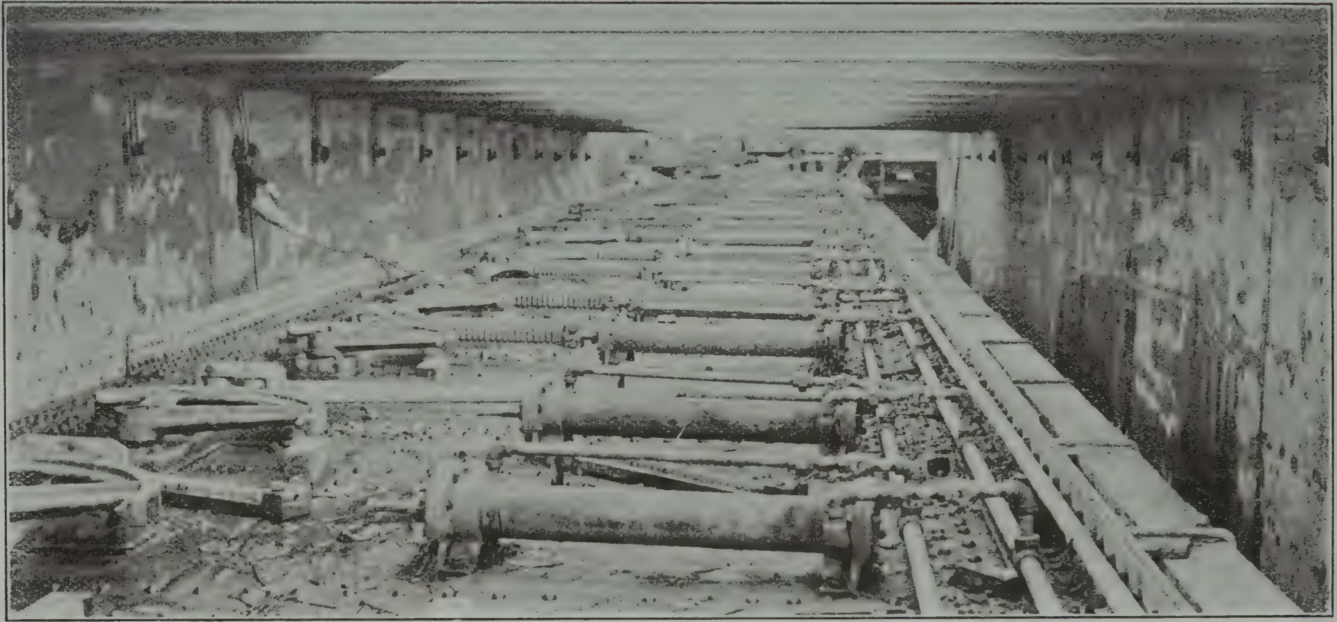
Vol. III APRIL-JUNE, 1911 No. 10

PROFESSIONAL MEMOIRS

CORPS OF ENGINEERS, UNITED STATES ARMY
AND
ENGINEER DEPARTMENT AT LARGE

Published Quarterly at the Engineer School
Washington Barracks, D. C.

Entered as Second Class matter January 1, 1910, at the post-office at Washington, D. C., under the act of March 3, 1879.



TOP OF LOWER GATE, DAM No. 8, OHIO RIVER, SHOWING VALVE-OPERATING MECHANISM

Furnished and Installed by

NEW JERSEY FOUNDRY AND MACHINE CO.
90 West Street, cor. Cedar, New York.

"DIAMOND N" EXPANSION BOLT

A better shield at the same price.
The parts can not become separated in transit.
Securely clamped together without the use of springs or wires

THREE IMPORTANT IMPROVEMENTS

1. The corrugated exterior surface at the inner end secures a tighter hold than was previously the case with a series of points.
2. The longitudinal ribs at the outer end of the shield, being larger in diameter than the corrugated end, bind in the wall and prevent the shield from turning when the screw is being inserted.
3. The clamping lugs at the side prevent the two parts from becoming separated, and do away with the use of springs or wires.

Now Ready for Immediate Delivery

Diamond Expansion Bolt Company, 90 West St., cor. Cedar, New York

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FOOL PROOF
REINFORCING
NORTHWESTERN EXP MET. CO. CHICAGO

In flat sheets, easily handled and placed.

TRADE KNO-BURN MARK
Metal Plastering Lath

The best and most favorably known.

Made in Four Gauges.

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NORTH WESTERN EXPANDED METAL CO.,
930 OLD COLONY BUILDING,
CHICAGO, ILL.

"Licensed Under Golding Patents"

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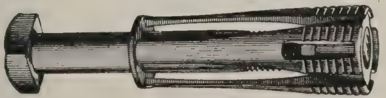
Specified as the standard Leather Soled Rubber Boot by the *UNITED STATES GOVERNMENT*

The *only sewed leather soled* Rubber Boot made in a factory that has *never made a second grade*

Send for catalog and prices

RUBBERHIDE COMPANY
Dept. J BOSTON, MASS.

SOMETHING NEW—BETTER
IMPROVED EXPANSION BOLTS



MACHINE BOLT
$\frac{5}{8}$-inch and larger, 4 side expansion

Our bolts fasten material securely and tightly, as the case does not expand until head of bolt comes in contact with material.
Machine bolt cases are practically one piece.
New lag screw cases have double expansion nut and case. Both have *real* expansion. Standard bolts fit our cases.
Sold complete or case only.

BROHARD CO., ... Philadelphia, Pa.

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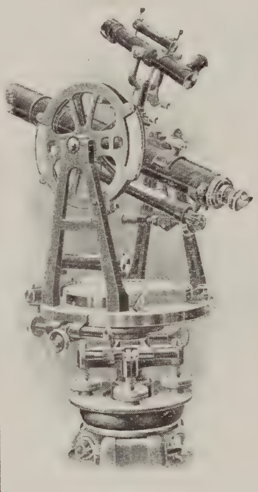

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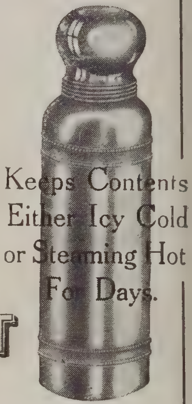

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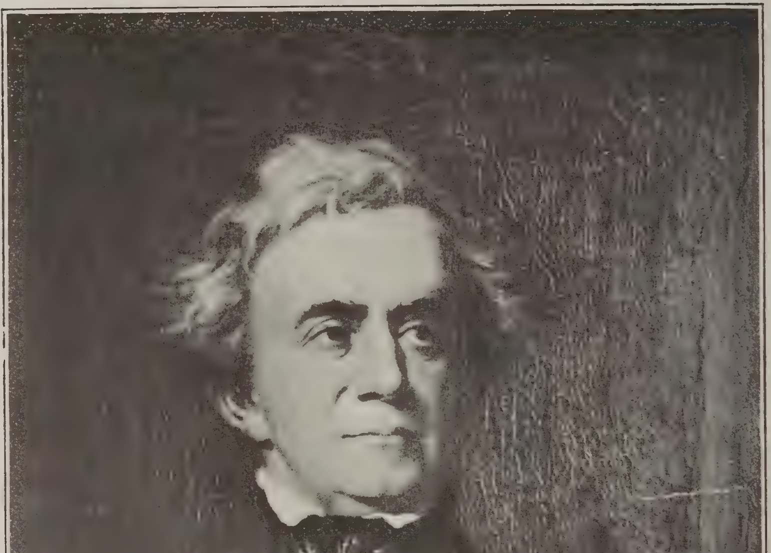


BRIG. GEN. JOSEPH GILBERT TOTTEN
CHIEF OF ENGINEERS, UNITED STATES ARMY
1838-1864
BORN 1788 — DIED 1864

NOTES ON CREOSOTING

BY

Mr. C. M. DAVIS
Assistant Engineer

Notwithstanding the increased use of iron, steel, and concrete as materials of construction, the use of wood has not decreased and still retains its most important place. The annual consumption has reached forty billion feet per annum, an increase in per capita use of about 20 per cent in ten years. With the increasing price of timber must come greater effort at prolonging its life through the use of preservatives.

Coincident with the exhaustion of the forests comes the decrease in the quality of timber obtainable. The efforts at reforestation are made with an inferior grade of timber, which can not be put to the same uses as heretofore without preservation from decay. The increased cost of labor makes the item of renewals more expensive than ever before, and forms another most convincing argument in favor of preservation.

As a preservative, creosote is pre-eminent. There are at present nearly sixty plants in the United States treating with creosote, more than two-thirds of which use it exclusively. The number using other methods is small and, usually, the preserving agent is specially adapted to the use of the work turned out.

The rapid growth of the Gulf ports in commerce and the consequent need of marine structures, has served to bring out a type of construction cheap in first cost and economical in service. The lack of solid foundation, also, has forced the construction of the present type of wharves and bridges founded on timber piling.

The destruction of timbers in these waters by the Teredo, Xylotrya and Limnoria is very rapid where they are not properly protected. This rapid destruction has brought forward various methods of protection, resulting in many failures and, in some cases, success. It was early learned that the "cabbage palm," growing on the nearby coasts, was immune from destruction and, consequently, at an early day there were in use wharves constructed on piling of this

material. Resisting destruction from marine life, they failed utterly through decay in the air, becoming in a short time soft and fibrous, incapable of sustaining the weight. Just why the teredo did not bore this wood is not known. Many theories are put forward, among which is that the fibrous nature of the material prevented the boring of the teredo. This theory is also advanced as to the protection of the timber for a time by the bark left on the piling when driven, but what are we to think of it when shown samples of manila rope honeycombed by teredo?

Various paints have been applied to protect, and for a time many have protected, but are subject to a constant renewal impossible in permanent structures under water. Castings of metal, such as copper and "yellow metal" have been used with more or less success, but the covering is so easily broken that its use is not economical. Of the various methods now in use after years of trial, there yet remains the protection by an iron or vitrified tile armor and the impregnation of dead oil of coal tar, commonly called creosote. The use of creosote is decidedly the more usual and economical and shows the best results in nearly every case at about 60 per cent of the cost of the vitrified tile protection. The use of cast-iron pipe is, of course, much more expensive than with vitrified tiling, but the results are much better. Such protection is used to a great extent on all the beacons built by the Light-House Establishment.

In structures subject to shocks and floating débris, creosoted piling is, of course, far superior to any other protection. For this reason, and that of cost, the use of creosoted piling is almost universal.

The keen competition among the various companies treating timber with creosote has led in many cases to faulty work. There are also some cases where faulty work has been caused by ignorance of the business, and it is of vital importance that the engineers in charge of the works utilizing the creosoted timber, ascertain that their specifications are proper and that being proper they are carried out. It has been the experience of the writer that the usual specification is prepared without a definite knowledge of the subject at hand, and this view is borne out by the extreme variance of the specifications and the manner of enforcement. Even the various engineering bodies, more or less connected, have such radically different views that one engineer excludes a property which another requires.

The writer has spent considerable time at treating plants and met many men stationed there for the inspection of creosoting. Usually they have been conscientious and seemingly capable men, usually interested, but they were, like the writer was in the beginning, inexperienced in the work and without the proper means of gaining experience. Often the plant management wishes them kept in ignorance; often the plant management is in ignorance regarding the points vital to the inspector. For instance, the specifications all call for a certain number of pounds of creosote per cubic foot of timber, but the writer has never met an inspector who took into consideration the weight of the creosote *at the time of injection*, but calculated the weight of the measure on the basis of cold creosote. Of course, there are probably many inspectors who do consider the change of volume due to heat, but they are in the minority.

The inspectors are not altogether to blame for their lack of knowledge, as there is probably no inspection quite so complicated and common, on which so little has been written of the practical operation and of which so many incorrect statements have been published.

The primary object of this paper is to assist, if possible, those engineers, who, like the writer, have been endeavoring to obtain timber treated uniformly and well. It is not the intention to argue the pro and con of the value of creosote as a preservative, and much less to exploit a certain brand or class of that article. It has been demonstrated time after time that a properly creosoted timber is to be classed with the building substances which enter into permanent structures.

Just what quality of the creosote or what portions—if it is a portion—does protect the timber from the various vegetable and animal destructors, has not been determined to the entire satisfaction of the engineering profession. In a measure, we are in ignorance regarding the very foundation of one of the most important industries pertaining to the conservation of natural resources.

The experience of the writer has been largely with the heavy treatment in vogue at the Southern ports of the United States, which treatment is primarily intended to prevent the destruction of the timbers placed in the xylotrya, teredo, and limnoria infested waters of the Gulf of Mexico and other nearby waters. It is probable that these elements of destruction are more active on the Texas coast than in any other portion of the United States. Even

temporary work, intended for not more than sixty days use, in the warm season must not be left exposed.

Along the Galveston wharf front may be seen the results of many experiments designed to give the desired protection. Dating back some sixty years may be noted the use of the cabbage palm (*Sabal palmetto*) which has been used for wharf piling. After fifty years the teredos have failed to make an impression on them. In fact, I have never yet seen a piece attacked beyond the bark.

Piling covered with copper and yellow metal have failed to give the service expected of them. Iron and vitrified pipe armored piling have been used, but are found to be more expensive and less serviceable when subjected to shocks than creosoted piling. The use of a resin and creosote mixture injected just as in full cell creosoting has proved an expensive experiment and at present the only method in use is the plain creosote process.

The experience at this port with the full cell process dates back some thirty-five years and the examples of the earliest work are the best arguments in favor of the effectiveness of the treatment. The extent of the treatment in pounds per cubic foot probably was not recorded, even at the time of treatment. The records on the subject indicate that the maximum quantity possible under the conditions existing at that time, was injected, and judging by the penetration and quantity of oil present now, was probably 20 or 22 pounds. The quantity injected into the same class of material at the present time varies from 20 to 27 pounds per cubic foot for marine work and 10 to 16 pounds for material not subject to marine borers. The quantity of creosote necessary to protect material varies with the uses of the timber and the degree of permanence desired. In the treatment of ties the quantity usually injected varies from 6 to 12 pounds. The use of a treatment as light as 6 pounds involves such a large proportion of plant expense that for the additional life gained the expense usually renders it uneconomical. In many cases the economy is limited by the life of the tie from mechanical wear. Bridge timbers which are to be framed should either be shaped before treatment or additional penetration be allowed for the necessary cutting involved. Application of a preservative to surfaces exposed in framing or in cutting off piling is good practice, but can hardly be expected to render the same protection as the deeper penetrating treatment.

The extent of marine treatment necessary will vary with the activity of the marine borers. In the cooler waters of the North

the attack is much weaker and more interrupted than in the warmer waters. The argument that protection is gained by a zone of impregnated wood, no matter how thin, is true to a very limited extent, as some allowance must be made for loss by evaporation and wash, and the exposure of untreated wood by checks and abrasions. An examination of exposed piling will often show instances in which the untreated center has been honeycombed, thus shifting the entire load on to the treated shell.

The results, as regards penetration, obtained in treating a cylinder load of piling are by no means uniform. For no apparent reason one stick will be thoroughly penetrated while another, alongside it, will be penetrated but a small distance.

A large quantity of creosote within the piling serves as a reservoir from which to replenish that lost from the exterior by wash and evaporation. If the center is not penetrated during the treatment a portion of it will be later, caused by the movement of that oil in the penetrated part.

Fig. 1. Sections of the same pile taken above water, in water, and in ground, illustrating failure through the abrasion of the protective coating in light treatment and, also, the greater penetration of the point as compared with the butts.

A 24 pound treatment will practically penetrate all the timber. For this reason it is usual to unject about that quantity where the best results are desired. The penetration of sawn timber is so varied on the sap and heart faces that in marine work it is absolutely necessary that practically all of the timber be penetrated, or it will be found that after a short exposure the slight penetration on the heart side has lost its effectiveness. Contrary to the opinion of many, it is possible to handle timber in such a manner that an injection of 24 pounds can be made without destroying the strength of the timber. This may even be done with long leaf

heartwood, although there are very few plants able to do it satisfactorily.

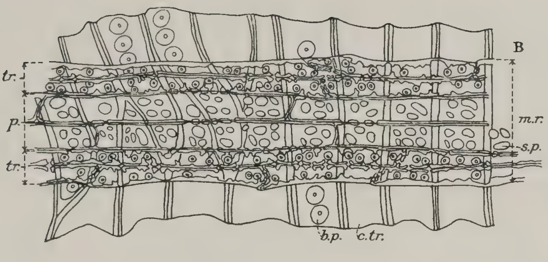
The success of any treatment is largely dependent on the management of the treating plant and the equipment of the plant. This is especially so in the heavy treatments, and under no circumstances should an order be placed where confidence can not. The writer knows of more than one instance where the price bid was barely enough to cover the cost of the timber and oil. In such cases the purchaser may be reasonably sure of poor work—probably not more than half the quantity of oil and that of poor quality. The necessity of careful and competent inspection can not be underestimated. Such inspection will be welcomed by any conscientious treating company.

THE MATERIALS

The timber.—The timber to be creosoted is usually one of the varieties of pine, though occasionally cypress, gum or oak are treated for ties or special uses.

The varieties of pine called longleaf pine (*Pinus palustris*), loblolly pine *(Pinus taeda)*, shortleaf pine *(Pinus echinata)*, and in a portion of the territory the Cuban pine *(Pinus heterophylla)*, differing in local names and texture even among the same variety, all creosote with facility and success. It is probable that in the past too great stress has been laid on the species of timber to be creosoted and too little attention been given to the structure of the timber.

A study of the structure of the timber is necessary to the proper handling of the material throughout the treating process. With regard to pines strictly, and to most timber in general, it is to be noted on microscopical examination that the wood substance is made up of small cells laid side by side, the majority of which extend in the same direction. These cells are connected radially by openings called ''simple pits'' and ''bordered pits'' covered by a very thin membrane, which openings serve as waterways between the cells. The openings between the ends of the cells are larger than the side openings, thereby allowing a more rapid longitudinal communication. In addition to these openings there are the medullary rays, composed of a number of cross cells radially placed and forming a means of radial communication. The medullary rays of the pines are much more numerous than one would expect on casual examination, there being an average of



Radial Section

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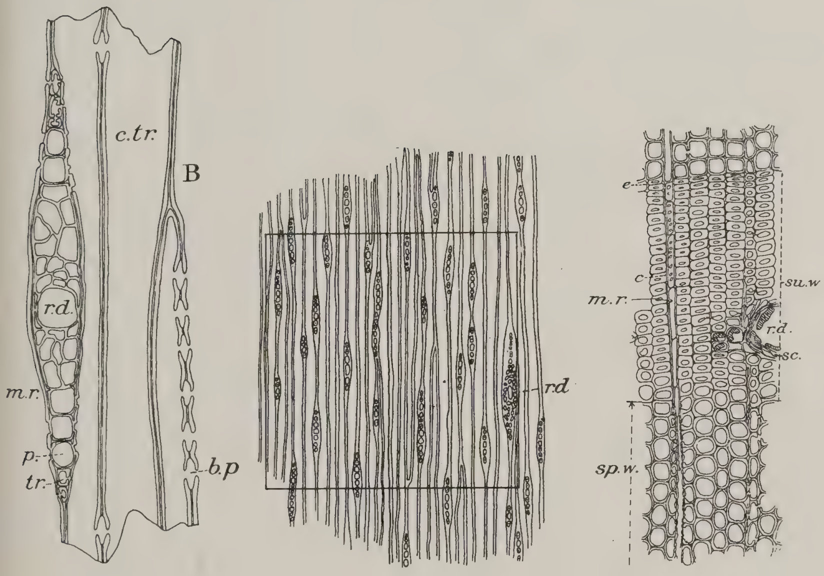

Tangential Section $\frac{300}{1}$ Tangential Section $\frac{85}{1}$ Cross Section $\frac{75}{1}$

Plate I. Radial section: *Pinus taeda;* m. r., medullary rays; tr., tracheids; p., parenchyma of the rays; s. p., simple pit; b. p., bordered pit; c. tr., common tracheid.

Cross section: *Pinus taeda;* r. d., resin duct; m. r., medullary ray; c., sample pit connecting the parenchyma cells of the ray; e., junction of the summer wood growth of one year and the spring wood growth of the year following; su. w., summer wood; sp. w., spring wood.

Tangential section: 300-1. Letters as above.

Tangential section: 85-1. Illustrating the frequency of the medullary rays and the resin ducts.—*Arranged from Filibert Roth.*

This plate has been reduced one-third in reproduction.

more than 15,000 per square inch of surface of those not containing resin ducts and about 400 per square inch of those containing cross resin ducts. Each of the smaller, or plain, rays are about ten cells in height and one in width, while those containing resin ducts are very much larger. The cells of the medullary rays have openings into the vertical cells, allowing a free and easy communication from the exterior to the interior cells. The resin ducts are large openings which allow the collection and flow of resin. They are much more numerous longitudinally than radially and are present in only a few of the coniferous woods, such as the pines and spruces. The presence of these ducts in the pines and the absence in cypress, firs, and most of the other woods, probably accounts for the radically different treatment the other woods receive when treated in the manner the Southern pines are treated.

The creosote does not enter the cell walls when it is injected into the wood, probably for the reason that the moisture has not been extracted from the substance, but only from the cells. Probably in time the moisture from the cell walls escapes and then its place is taken by the creosote, provided a sufficient excess is present and it has not hardened in the meantime.

Examination of treated wood will show a seemingly peculiar fact in that the harder or summer wood seems to contain a larger percentage of the creosote. This is accounted for, probably, by the nature of the structure of the wood. The cells of the spring wood are larger and the walls are thinner than in the harder summer wood. The quantity of creosote is regulated by the size and number of the openings into the cells, the quantity in each adjacent cell being approximately the same and, owing to the relative scarcity of openings in the larger cells, the proportion of oil is much smaller in the larger cells of the spring wood. The more porous wood would therefore seem to contain the smallest portion of the creosote. The longitudinal resin ducts are much more numerous than the side or cross grained resin ducts. This arrrangement of cell openings and resin ducts will account for the greater ease with which the creosote penetrates longitudinally in a stick of timber .

The sapwood is the live wood of the tree, while the heartwood is practically dead. The structure of the two is identical, since the sapwood gradually merges into the heartwood, hence the darker color of the heartwood is not caused by a heavier cell but by the staining actions of the chemical substances. The sapwood

contains the most moisture, the cells of the heartwood being practically empty. Therefore, in the extraction of the moisture from the timber the cells of the sapwood are easily broken open, leaving the openings ready for the infiltration of the creosote, while the cells of the heartwood, containing little moisture, the membrane closing their intercellular openings is not so easily broken and, as a result, the heartwood is much harder to penetrate.

The end penetration is also aided by the more rapid seasoning of the cross-section of the timber, as the moisture evaporates more rapidly from the cross-section than from the radial section and faster from the tangential section than from the radial.

The closer grained timbers, such as the long-leaf pine, are more difficult to impregnate, provided all other things are equal, as the cells are smaller, but the tendency to retain oil is much stronger than in the coarse grained loblolly and consequently the protection is better. For this reason it is a mistake in some cases to select the easily impregnated wood. An examination of about 1,500 piling taken up and cut off after seventeen years service in teredo infested waters showed that those attacked were of the coarse grained variety, though the penetration was greater than in the fine grained. The attacks extended only for a slight distance into the outside, showing that the oil had leached out from that part. On being drawn by means of a jet, a large quantity of creosote was found to be in the sand next to the piling and from the excessive penetration in the points it was evident that this oil next to the sand and the excess in the point was due to the downward infiltration of the creosote from cell to cell. The quantity flowing from the end of the drawn piling varied, but in some instances a pint or more would run off the point.

The fine grained wood, retaining the oil longer, is therefore more suitable for exposure to wave action. The loblolly pine—if it be the wide coarse grained kind—takes oil more freely than any other class of wood and, consequently, less steaming is usually required, and if the quantity of oil required is so great that excessive steaming is necessary the resulting strength is not necessarily less than the longleaf pine, but the loss both by evaporation and wash will be much more rapid.

The greatest care should be exercised to obtain timber which has not been injured by decay. In the warm, damp atmosphere of the Gulf Coast it is almost impossible to keep timber for any length of time greater than, perhaps, one month without decay. If the

timber is cut and left in the woods with the bark on, it very rapidly deteriorates and in a remarkably short time is entirely unfit for treatment, especially if the treatment be heavy.

All the timber in a charge should be as uniform in grain and seasoning as practicable to get it. All loblolly is not coarse open grained wood but, on the contrary, much of it is very similar to the coarser pieces of longleaf timber and has almost as large a proportion of heart and resin. It would be much more correct to specify a pine wood of a given number of rings per inch than to specify the species of a wood of great variation in texture.

The weight per cubic foot of pine wood varies from 27 to 33 pounds per cubic foot, the smaller figure for loblolly sapwood, and the larger for longleaf pine heart. The removal of the resin will reduce the figures till they are probably about the same, the specific gravity being about 1.6 for all the pines. The variation of cell capacity is comparatively slight, the cells in the coarser grained loblolly being larger and proportionately heavier than in the fine grained longleaf.

Fig. 2. A break caused by treatment of timber which had been left on the ground and decayed. Note the brittleness of one side as compared with the elasticity of the other. Some of the strips on the lower side were 12 feet long.

The quantity of wood substance being the same (nearly) for all the pines, the quantity of oil possible to inject into the various species should therefore be about the same. The quantity possible to inject seems to be limited by the quantity of saps and

resins extracted; if all of these substances were completely extracted there could be at least 42 pounds of oil injected. In practice, however, it seems that about 27 pounds is the greatest amount possible to inject; therefore, there must be about 15 pounds of saps and resins left in the timber after subjection to the seasoning process used for that heavy impregnation.

It is not the intention of this paper to advocate the treatment of green timber exclusively, but aside from the impossibility of obtaining the air-seasoned timber for treatment there is the difficulty of properly seasoning in air. The damp atmosphere of the Gulf Coast timber belt is very destructive to the wood fiber. Decay begins immediately the tree is felled, and at most seasons of the year it is practically impossible to handle the timber in a manner to prevent serious damage. The experience of the writer has been such that green timber is always favored and required in the case of heavy treatment. Partial rot, perhaps so slight as not to be noticeable, will develop weakness under the steaming necessary in any case to such an extent that the timber is rendered practically useless. Instances are seen time and time again in the heavy treatment process, in which piling, handled in the best possible manner—a few months intervening between the felling of the tree and the treating—were found on treatment to be so far decayed that they could not be picked up in the center without breaking. Usually this condition is attributed to over-steaming, or excessive heat during vacuum, but the writer would venture the opinion that nearly all of the cases of timber burned with live steam are really cases of rotted timber. This is borne out by the fracture itself, and at this point reference is made to the photograph shown in Fig. 2, in which it will be noted that one side of the piling was brittle, while the other was exceedingly tough—indicative of decay.

The frequency of these occurrences and the uniformly good results obtained from treating the green timber leads the writer to recommend for heavy treatment, such as is necessary for marine work, the use of green timber exclusively, as the one safe method of obtaining protection and strength.

Considering the foregoing facts regarding structure and the deductions relative to extractions of the saps and resins, it will appear that for the injection of the maximum quantity of creosote the use of timber containing a large percentage of moisture is desirable. This deduction is borne out by experience. If the moisture is

extracted by long, low heat, such as the exposure to the atmosphere, it will be noted that only the volatile elements are extracted, leaving the heavier gums and resins which will seal up the outlets of the cells and form an effectual barrier to the entrance of the creosote.

Instances of increase in weight of timber after the steaming and vacuum processes are numerous where air-seasoned timber is being treated, yet these air-seasoned pieces will not take as much oil in many cases as timber put into the cylinder in a green state. If air-seasoned and green timber are treated together, the steaming being gauged by that necessary for the green, the penetration is almost invariably greater in the green sticks than in the dry, pro-

Fig. 3. Section through creosoted seasoned piling. This piece was in the same charge as Fig. 4. Note inferior penetration.

vided the quantity of oil injected into the entire charge is the limit.

Some time since the writer had occasion to cut an entire charge of piling which had received 14 pounds of creosote per cubic foot of wood. The piling were more or less air-seasoned and the steaming required was just sufficient to properly sterilize the timber. It was a mixed lot of timber, the remnants of several previous orders, and of rather varying degrees of seasoning—some of the piling being ''bone dry,'' having checks reaching one-third the distance to the center, while others were not checked at all. The exposure of the penetration developed several remarkable facts: *first*, the greenest wood was the deepest penetrated; *second*, of the dryer sticks, those having blue sap, though they seemed most porous, were the least penetrated of all, some not more than one-fourth of an inch as compared with an average penetration of 2 inches for the lot. Photographs of these sections are given in Figs. 3 and 4.

Pitch streaks or ''fat'' butts render the timber unfit for marine treatment, as the ordinary steaming required for the general run of the charge will not remove the resin sufficiently to allow injection of enough creosote to prevent attack by marine borers. Pitch acts as a preservative against rot, but is not so against teredo. Some fifteen years ago attempts to make a teredo-proof pile by the injection of a mixture of creosote and resin were made, and proved a total failure. In some instances the treated timber did not last longer than that which was untreated and in no instance, so far as the writer has been able to find, has the treatment been successful.

Examination of piling which has stood the test of years of exposure in teredo infested waters, will often show signs of attacks where knots were exposed, undoubtedly due to the presence of resin pockets.

The oil.—The use of creosote is greatly hampered by the lack of knowledge, both of the oil itself and the methods of use. The Egyptians, Greeks, and Romans used preservatives of the same nature and must have gained their knowledge of them from the same sources as the modern engineer—from experience. Of the twenty or more direct constituents of the commercial oil, called ''creosote,'' we do not know the relative value of each for preservation. Beginning with the oil itself, the creosote tank is the refuse pot for coal tar products. Those constituents which can be made to serve as personal adornment, as the dye-stuffs and

perfumes; for bodily comfort, as the medicinal preparations; or for luxuries, as gas and the manufacture of ice, are carefully studied by scientists of international reputation. After these uses are satisfied, the residue—smoke, sludge, dirt and the unknown materials—is given the engineer, for him to find by blunt experience the proper use for the most permanent work of all. Were it not for the ever-changing makeup of this residum as new uses for certain heretofore wasted compounds are found, it would be possible in the course of time to discover by simple experience the combination giving the greatest service for the least expense.

Fig. 4. Section through creosoted green piling of same charge as Fig. 3. Note superior penetration of creosote over that shown in Fig. 3.

The need of scientific work which does not look to the production of a color heretofore unknown, or a nostrum to relieve pain in mankind, is expressed in the present controversy as to the value

of certain constituents of the oil called "creosote," with which the literature on this subject is replete.

Looking backward, we find that the modern use of coal tar products for wood preservation dates back to Lebou, who, in the latter part of the 18th century, suggested the use of coal tar itself as the preservative. At this time there was practically no use for this product. As new uses for portions of the tar developed, the residum has always been sold and recommended for timber preservation, the consumer having no choice in the matter whatever. This is the situation to-day to a large extent, varied only by the extent certain industries in different countries make use of the component products of coal tar.

The oil called creosote or "dead oil of coal tar," as it is sometimes called, is obtained from the destructive distillation of coal tar obtained in the manufacture of coal gas and coke.

The tar is a varying compound depending largely on the method used in distillation, which in turn is largely dependent on the coal itself. The presence of water and a large quantity of light hydrocarbons in the tar necessitates a preliminary distillation by steam heat in many instances, while the intensity of the applied heat influences to a degree the constituents as well as the quantity of each fraction.

The fractions taken vary according to the uses to which it is expected they will be put. The following fractions are separated at some works, while others combine or else use a slightly different temperature.

a. First light oils	over at 100° C.
b. Second light oils	over at 149° C.
c. Creosote oils	over at 171° C.
d. Anthracene, or green oils	over at 204° C.
e. Black oils, or last runnings	over at 425° C.
f. Pitch	Residue

The temperature given is that at which the receivers are changed and is indicated by a thermometer placed just above the tar at the beginning of the distillation and does not, therefore, give the temperature of the vapor passing from the still head. It may be noted in this connection that a distillate of a higher boiling fraction may pass over during the distillation of the lighter fractions so that the temperature as noted by the thermometer at the time of changing the receiver does not represent the maximum degree of heat necessary to vaporize that fraction. This is a point that

must be considered in fractional distillation for testing creosote samples.

The specific gravity of the tar usually varies between 1.10 and 1.20, though that from Scotch cannel coal is sometimes as low as .95. The specific gravity of the fractions does not increase regularly with the increasing temperature of the distillation, though the tendency is in that direction.

PRODUCTS OF NEWCASTLE COAL WHEN CARBONIZED FOR THE MANUFACTURE OF COKE

The principal products which can be separated as they come from the still by distillation and filtration:

- COAL:
  - Coal Gas.
  - Gas Liquor—
    - Ammonia.
  - Coal Tar—
    - *Oils lighter than water. (Distilling from 0° C. to 170° C.)
      - Benzol,
      - Toluol,
      - Xylol,
      - Cumol,
      - Pyridene,
      - Carbolic acid,
      - Cresylic acid.
    - *Oils heavier than water. (Distilling from 170° C. to 270° C)
      - Carbolic acid,
      - Cresylic acid,
      - Other tar acids,
      - Naphthaline,
      - Quinoline Series.
    - *Green oils. (Distilling from 270° C. to 400° C.)
      - Phenanthracene,
      - Carbazol,
      - Anthracene,
      - Acridene,
      - Pyrene,
      - Chrysene,
      - Benzerthrene.
  - Coke.

The creosote oil.—The oldest specimens of treated timber in the waters of the Gulf of Mexico were treated with creosote oil imported from England. It contained a high percentage of solid naphthalene, as evidenced by the solid contents of barrels in which it was shipped. It is probable that the amount of naphthalene present in the present day creosote is not so high as formerly, but records of tests by distillation of these old oils are, no doubt, of little value to us to-day, as the methods of sampling and analysis are not now the same.

Creosote is being used in the preservation of timber from two radically different causes of destruction, and by all means they should be considered independently—the decay of timber caused

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*Temperature by thermometer of still above and close to the surface of the tar.

by the vegetable organisms, the bacteria and fungus on one hand and on the other the animal organisms, such as the teredo and limnoria. It has been ascertained that antiseptics prevent the vegetable decay, though the knowledge on that subject is rather limited with regard to creosoting, and experiments with the different ingredients of creosote seem to show that the phenols and crysols, though they are of the greatest antiseptic value, do not preserve timber as well as some of the other portions.

Creosote certainly is not poisonous to any great extent to the teredo. Instances of attack of well-treated wood, in which a full-grown teredo passes from untreated wood and through treated wood, are frequently seen. They evidently do not bore for food, but for a habitation, the débris carried out by the siphon probably not having any marked effect on the borer itself. It is reasonably certain that creosote prevents attack to a large extent by filling up the pores of the wood and thus preventing the lodgment of the teredo in the first place. This protection would then be mechanical. Creosote is no doubt odious to the teredo, for on striking a creosoted strata they usually quickly turn from it back into the untreated wood, and if that is lacking they will soon quit boring and die. It is possible that the action of the creosote is entirely mechanical, inasmuch as impregnated wood, having the pores completely filled, is in such a condition that the teredo can not bore in it for any great length of time. In any event, protection of marine work and prevention of decay are different problems and should be studied as such. A case on this point recently came to the notice of the writer through a treatment made with large percentage of water in the creosote. After the evaporation of the water the wood was left dry and porous, but still contained much creosote resisting decay but failing on exposure to marine borers.

From the evidence at hand it seems that a creosote having a high percentage of solids at the ordinary temperature would resist destruction in sea water longer than the more liquid creosotes. In all of the cases of well protected piling in long use on the Gulf Coast the creosote used had a high percentage of naphthalene, so much that when the barrel in which it was imported fell to pieces the oil was solid enough to stand without support. In the absence of better information should we not conclude that such an oil is the proper one to use at the present time in similar positions?

The anthracene is less volatile than the naphthalene fractions and should stay in the piling longer on exposure. There is quite

a loss of creosote from the outer portion of pile, caused by the wash of the waves, and this loss is just at the point of greatest activity of the teredo. As stated previously, the loss from the finer grained woods is less than from the coarse grained, since the effect of capillarity in the smaller cells tends to retain the creosote. If the creosote were solid the capillary action would not be active and, consequently, the oil would not come to the surface of the wood to be washed out.

On account of the solidification of the oils and also the separation into strata of the different oils, the oil in the tank should be kept hot and liquid. After some months without heat or stirring it will be found that the portion on the bottom of the tank is hard and solid—in some cases so hard and solid that it must be broken out with a pick. Table A shows the variation of distillation of sample taken from various depths in a large storage tank.

TABLE A.—*Comparative analysis, showing the separation of Creosote Oil in a Storage Tank.*

A. Analysis at time tank was filled, oil thoroughly mixed.
B. Four months later, 6 feet below surface.
C. Four months later, 20 feet below surface.
D. Adhering to sides of tank near top after tank was partly emptied.

	A	B	C	D
Water	*	*	*	.000
Oil:				
—— to 170 degrees Centigrade	.01	.006	.001	.015
170 degrees Centigrade to 205 degrees Centigrade	.06	.075	.036	.010
205 degrees Centigrade to 225 degrees Centigrade	------	------	------	.804
225 degrees Centigrade to 245 degrees Centigrade	.45	.492	.388	------
245 degrees Centigrade to 270 degrees Centigrade	.15	.099	.172	------
270 degrees Centigrade to 315 degrees Centigrade	.17	.168	.164	------
Residue	.16	.160	.216	.165
Specific gravity	1.050	1.037	1.042	------

*Trace.

Not able to obtain sample of hard oil in bottom of tank.

Analysis by same person and same apparatus. 500 c. c. Side neck distilling flask with thermometer at the outlet tube. Distillation at the rate of 1 to 3 drops per second.

Most storage tanks are open at the top, and, for prevention of fire, the top is kept covered with a few inches of water to which is added from time to time the quantity caught by rains, usually more than the portion lost by evaporation. Ordinarily water does not mix with the creosote, owing to the higher specific gravity of the latter, but it will be found that after some months the water from the top of the tank has gone down into the creosote for quite a distance, so that water will be drawn off with the upper portion

of the oil. This proportion of water is rather difficult to separate from the creosote, as ordinarily it will not settle on top to be drawn off. Probably after several months time there has been formed an emulsion which tends to keep the mixture stable.

The presence of large percentages of water in the creosote will probably account for more failures in marine work than any one thing. At nearly every step in the treatment process the tendency is to increase the percentage of water, and most people connected with the business have such unbounded faith in the separation by settling that they neglect to examine the oil to see if it really does separate. Clean water will separate, and does so very rapidly, but water charged with saps and resins, mixed with the oil hot and stirred by being pumped back and forth betweeen tanks and cylinders, will not separate unless some special means are employed. Usually, the plant has a chemist employed to ascertain the condition of the creosote, but very often he does not keep up with the changes closely enough and the result is that a treatment is made with a large quantity of water in the creosote. It is not unusual to find 10 per cent, and the writer has found more than 20 per cent on several occasions.

The presence of water does not necessarily render the treatment valueless, but aside from the fact that the quantity of oil specified is not injected, the treatment approaches the open cell process, the value of which as a protection has not been fully determined in all cases of exposure. Very recently two cases of failure of creosote as a protection from teredo caused by a high content of water came within the notice of the writer. The first one was of piling treated some twenty-five years ago, which within a few years, were attacked and would have been destroyed had not the additional protection of vitrified pipe been applied. The writer saw some of these piling removed and sawed recently, and the section showed such little signs of creosote that he did not know at the time that they had ever been creosoted. The wood was scarcely discolored. The creosote must have contained fully 50 per cent water at the time of injection.

In the second case the piling, after treatment, did not show the presence of creosote to any marked degree. The sections *after months of exposure* showed a light brown color, and after two years were attacked and practically destroyed by teredo. Instances of this sort caused primarily by lack of proper inspection cause the failures, and the wrong interpretation of these failures has tended

to make engineers doubtful to a great extent of the efficiency of the protection afforded by creosote.

Speaking from a practical standpoint, it is more important to ascertain that the creosote used is *creosote* than to spend time and money buying a creosote from some certain place containing a stated proportion of the various elements. The light oils so often prohibited in specifications are more valuable than water, and yet in practice under these same specifications the water is often injected.

Many engineers have an idea that creosoted material should appear black and slick. Usually, these same engineers limit the amount of free carbon in the creosote and would offer strenuous objections to the addition of any quantity of tar or pitch; yet it is the free carbon, tar, and pitch which makes the timber black. Commercial creosote, which has not long been exposed to the sun and air and has not been used in such a manner to become oxidized, will not leave the timber ''black and gummy,'' as so often wished for, especially when applied to dressed surfaces. The color and grain of the timber will often be apparent and yet it is not detrimental to the timber and is not indicative of faulty treatment. If ''pure dead oil of coal tar, free from adulterations'' is specified, one should not expect to find the timber ''black and gummy'' on its being withdrawn from the cylinder. It may become so when treated with *commercial oil* and exposed to sun and water.

The question of the value of naphthalene as a preservative from both the effects of decay and attacks of marine life is certainly an open one. Of late years many have questioned the value formerly placed on it, and no doubt there has been too much reliance placed on it, especially in marine work. It is true that the examples of well protected marine timbers we have, especially on the Gulf Coast, all originally contained large percentages of naphthalene, but certainly most of it has evaporated and at present only traces are found. It is possible that the very loss of it has been the means of protection, in that its action prevented attack by marine borers, yet it is certain that these timbers have long been without any large quantity and yet have been preserved. There will be found, after years of exposure, much of the anthracene portion of the creosote, due to its higher distillation point and consequent slower evaporation. Indications therefore point to that portion of the creosote as the most valuable, which opinion seems to be increasing in popularity.

At one time it was thought that the strong antiseptic powers possessed by the phenols and creysols were responsible for the immunity from attack by the vegetable fungi, but this theory has long since been exploded by the experiments made by the Belgian engineer, Mr. Goisne, who took shavings impregnated with the various portions of creosote and exposed them to a most favorable attack. His deductions were that the lighter phenols and creysols prevented decay, but did not long remain in the timber and that the greatest protection was afforded by those portions of high distillation, because they were just as efficient and remained present for the longest period of time.

In the open cell process, on account of the small quantity of oil left in the timber, impregnation should be made with an oil which is least volatile. For the full cell process the evaporation of small quantities is not so detrimental and a more volatile oil is permissible. The protection of marine work is another proposition, in that the portion exposed to the air—and therefore decay—has a great excess of creosote which, of course, can be more volatile, while the portion exposed to the water is less subject to evaporation and more subject to leaching out. It is very probable in this case that the solidifying quality, rather than volativility, is the criterion.

The measure of value is service, which can only be proven by actual experience. The accelerated tests made to ascertain the value of creosotes are probably subject to the same criticisms as the accelerated tests on cement. For marine work, in view of the lack of experience with the oils lacking in naphthalene, it would seem best to at least take a middle course and use an oil containing a moderate quantity.

Many specifications show a positive lack of knowledge of the fundamental principles of creosote. The specifications of an ''anhydrous oil'' of an absolutely pure dead oil coal tar having a higher specific gravity than is possible to get—as we frequently find in paving block specifications—are ridiculous. The specifications of a minimum quantity of low boiling oils is wrong in the face of experience. These specifications are in most cases uneconomical. Creosote, as a commercial product, is the oily residue after the extraction of the portions which are more valuable for other purposes and which, if required to be in the creosote must add to the expense thereof. One should ascertain the quality which may be had for the work in hand, and if more than one quality suit-

able for the particular work is to be had, then, the better the quality the less the quantity.

It is neither practical nor desirable to have adopted a uniform specification for creosote oil. Such a specification would increase the cost by excluding many of the oils now on the market and might tend to place the whole business in the hands of a few producers or their agents. The knowledge of efficiency of the oil has not advanced to a stage of certainty and even though it were known what is best, it probably would be found that the composition would vary according to the geographical location and the use to which the material was to be put. More irrational yet is the suggestion that in the present state of ignorance on the subject, no specification as to the constituents of the oil be made.

The standard specification of the American Maintenance of Way Association is open to criticism in that it practically excludes the great quantity of creosote produced in the United States and England, which even though it were not so efficient for their use, might be just as valuable in increased quantities and at a lower price. The writer will venture the opinion that where any effort is made to supply oils such as required in standard paving block specifications, the result is either failure or detrimental to the material through the trickery involved.

Many specifications will not allow light oils in excess of some stated per cent and yet allow the presence of a percentage of water without compensation, or a larger percentage with compensation. Why, then, is it not allowable to compensate for the presence of light oils in the same manner as for the water?

PLANT OPERATION

This paper is based primarily on the Bethell or full cell process, which is ordinarily used and unless otherwise stated, is the one meant whenever the creosoting process is mentioned. The treatment is made in large cylindrical retorts into which the timber is conveyed on small iron trucks or cars, called cages. The ends of the cylinder are closed tight by means of close-fitting doors capable of withstanding considerable pressure. If the timber has not previously been seasoned, it is usual to admit live steam into the cylinder for such time as the experience of the engineer in charge directs. On the exhaustion of the steam a vacuum is drawn, the heat in the cylinder being maintained by means of steam coils beneath the trucks. After the vacuum has been held a sufficient time,

creosote from a gauged tank is admitted and pressure held by means of a pump until the requisite quantity is absorbed by the timber. The excess oil is then returned to the tank from which it was originally taken, the gauge indicating the quantity absorbed by the timber. Variations of this process, known by various names, are used where peculiar conditions or theories warrant.

On the Pacific Coast the steaming process is replaced to a great extent by heating in hot oil, as the structure of the wood there treated is such that damage is done by the ordinary steaming process, probably due to the lack of cross ducts to relieve the internal pressure of volatilized moisture.

The preparation of the material for treatment is largely dependent on the extent of the treatment proposed and the nature of the timber to be treated. Care must be taken to keep the pieces separated in the cylinder so that the treatment may have the similar effect on all pieces to insure somewhat uniform penetration of the creosote. Dry timbers or timbers not to be steamed do not have to be spaced so carefully or so far apart as in the case of steaming. It must be remembered that during this process the timber becomes soft and will easily bend and that the more rigorous the steaming the softer the wood will become, and therefore greater precaution must be taken to prevent it from becoming misshapen or bearing down on the pieces underneath, thus preventing the full effects of the process or the penetration of the creosote.

Crooked piling can often be drawn back into shape by proper ''building'' in the cages and, on the other hand, many otherwise good sticks are rendered practically unfit for use by improper ''building.'' Some timber is, of course, more apt to go together and prevent the penetration of the oil, and for that reason should be carefully separated. The pieces used as separators will press into the timber and allowance must be made for that.

Piling intended for the lighter treatment—15 pounds or under—should be free from the ''skin'' found next to the live wood unless considerable steaming is done, as this skin will prevent the penetration of the creosote. Many failures—especially of telephone poles—can be attributed to the failure to observe this precaution, the decay in the spots unpenetrated passing in to the unpenetrated center of the pole and causing a general disintegration. In this connection it must be remembered that the creosote penetrates more rapidly the tangential section than the radial, owing to the arrangement of the resin ducts and medullary rays. Where the

treatment is heavy the creosote will gradually penetrate underneath the skin, provided the patches are not excessively large, though the treatment is delayed thereby. If rigorous steaming is given, the skin will usually curl up or peel off sufficiently to allow the penetration throughout. Many specifications limit the size of the skin to be left on to 1 inch in width, it being assumed generally that the creosote will penetrate ½ inch tangentially before the extreme depth of penetration is reached.

For the reasons heretofore given there should be a uniformity of texture and seasoning of the timber, especially in the case of light treatment, or else great variation in penetration must be expected. When, as for heavy treatment, the oil pressure is continued for a long time and the cells must all be filled to take up the required amount of creosote it will appear that this precaution is not so necessary, but the necessity of steaming the more porous wood longer, in order to properly treat the harder pieces and the possible consequent weakening, is an argument for separation.

It is most important that the timber of a charge be of approximately the same cross-section. The effect of steaming, vacuum, and injection are largely dependent on the area of surface exposed per square inch of cross-section. The same depth of penetration can not be expected in large timbers as in small—much less the same amount of oil per cubic foot of wood. Examination of the relative depth of penetration in the butt and point of a pile will show much greater penetration at the point. It is to be remembered that the effect of the heat is retarded by the mass of cold material within the large pieces.

The writer has before him a record of a charge of timber treated under the supervision of an inspector, which was composed of small cross-arms, ties, piles, and large square timbers. This charge was unseasoned material, steamed for ten hours with an injection of 18 pounds per cubic foot. Can anyone expect proper treatment under these conditions? In another instance ties of pine, oak, and gum, together with piling and large square timbers, some green and some air-seasoned, were treated together with a supposed uniform treatment of 12 pounds.

It is well for the purchaser to remember such instances as these quoted and endeavor to place orders in such a manner that no great difficulty will be found in segregating the material for treatment. If the order is small, it is well to ascertain the manner in which the material will be handled at the works and, in any event,

to specify some treatment not conflicting with the general working of the plant.

SEASONING

Steaming.—The question of whether to steam or treat material which has been air-seasoned must be settled from the conditions peculiar to the case at hand. The stock of timber carried by the various dealers is comparatively small, so that time for seasoning must usually be given if the air-seasoning method is adopted. The second consideration is whether or not the air-seasoning will be sufficient for the injection of the creosote, and, lastly, probably the most important of all, will the material air-season without decay?

Seasoning of timber in the open air will, under proper conditions, leave it free from a large portion of the moisture, but that solid portion of the sap and the resin will still be retained and will prevent the ingress of the creosote to some extent, though not enough to affect the lighter treatments. The heavy treatment for marine construction requires more than seasoning—the extraction of a large part of the resins and the opening of the cells for the injection of the creosote. This can not be accomplished by air-seasoning, though the time of steaming necessary may be considerably reduced. For lighter treatment air-seasoning is sufficient, though the subsequent oil penetration is never so uniform as when steamed.

In longleaf timber the outer inch may contain as much as 50 per cent of the moisture. The heartwood contains only about 20 per cent, practically all of which is contained in the cell walls. Ordinarily, about 35 per cent of the moisture may be found in the cell walls, though this percentage varies greatly, as it is influenced to a large extent by the quantity in the cells. From this it would appear that the problem of injection is largely a problem of extraction of the contained liquids. To open the cells and allow the liquid contained to pass off without tearing down the cell structure and to replace those liquids with the creosote is the problem.

It is with some hesitation that the writer expresses his opinions on the effect of steaming timber in the seasoning process, as there has been so much evidence put forth to prove that steaming is not necessary and is exceedingly detrimental to the timber. The subject of the effect of steaming on the strength of the timber was elaborately experimented on and discussed from a physical standpoint, in Forest Service Circular No. 39, by Dr. Kendrick Hatt, and much valuable information may be had therefrom. The writer has never been able to find a discussion of the effects on the struc-

ture of the timber and has not had the opportunity of investigation from that standpoint, except in a superficial manner, but has had ample opportunity to observe the practical effects.

The effects of different arrangements of apparatus, such as the distance from the sources of steam to the retort, the prevention of radiation from the retort, as affecting the character of the steam, has probably never been investigated, though the difference must be considerable. It is certain that steam passed through a superheater is more destructive than steam as it passes from the boiler. Why, then, should not the rapidity of condensation in the retort cause a variation of effect. It is obvious that a proper test of steaming can not be made without an examination of the structural change in the wood. The writer will venture the opinion that the pressure and, consequently, the temperature, is not the direct destructive agency, the greatest damage coming from the volatilization of the moisture in the wood cells rupturing the cell walls in its effort to equalize the pressure. Referring to the discussion regarding the structure of timber, it will be noted that there are certain openings between the cells called "simple pits," "bordered pits," and "resin ducts." When the moisture in the cells is vaporized it causes a pressure on the walls sufficient to rupture at some point, and, as the membrane covering the bordered pits is the weakest point, that portion is the first to give way. The resin ducts, principally the cross ones, also furnish a means of exit for the expanding moisture, as do the transverse cells of the medullary rays. If the steam is applied so as to heat the wood gradually, causing an expansion of the contained moisture, air, and resins only sufficient to break open the "pits" and force freedom through the resin ducts and medullary rays, the writer will venture the opinion that the structure will not be seriously injured regardless of the pressure finally attained.

The moisture, saps, and resins forced out of the wood evidently come from the cells alone, the moisture remaining, or even increasing, in the cell walls. Many recorded experiments show an increase in the weight of the wood after the steaming process, which may be accounted for by this increase of the moisture in the cellular structure. Most of this increase in weight in unseasoned timber must take place within the heartwood, as the sapwood is already nearly saturated. To say that steaming green timber fills the cells and increases the weight of wood is certainly erroneous in the class of work with which the writer has been engaged. The

following case, being one of many recorded, would no doubt serve to illustrate the case at hand.

A charge of 2,000 feet of green loblolly piling weighing 65 pounds per cubic foot, just a little too heavy to float, was steamed as ordinarily done for 24-pound treatment, and the vacuum applied in the usual manner. There was collected during the vacuum process about 1 pound per cubic foot of timber of condensed moisture in the bottom of the cylinder, a small amount, of course, coming through the vacuum pump as a vapor, but this quantity must have been considerably less than that collected from the bottom of the cylinder. The 24 pounds of oil per cubic foot were injected, and on being removed the piling weighed practically the same as when put into the cylinder. What became of 22 and a fraction pounds of moisture per cubic foot? This is not an isolated case, but is the case whenever waterlogged or sap-filled timber is treated, and to a marked degree whenever less moist material is given treatment to the same extent. This is the result of the actual treatment on a commercial basis, and is incontrovertible evidence that steaming as actually done in commercial operations does remove moisture.

If steaming sufficient to cause great loss of strength is applied to timber-piling, for instance, the heat very gradually penetrates to the center of the wood, as the wood is a rather poor conductor of heat, and as it becomes more heated it is poorer yet. There is no circulation of particles within, but on the contrary the moisture is usually outbound. The experiments recorded by Dr. Hatt, as previously referred to, seemed to indicate a difference in temperature of 40 to 50 degrees between the interior and exterior after some hours of steaming. The loss of strength would therefore be confined to the outer layers of wood and the central portion would not be injured for many hours. This is contrary to the facts as exhibited by specimens, which the writer has had the opportunity to see, said to have been ''burned'' by live steam, the wood just within the outer ring usually being brittle, as is the heart, which fact confirms the opinion that the damage, with the exception of a small percentage practically negligible, is caused by the sudden application and release of pressure.

In computing the strength of timber, it must be reduced to some standard percentage of moisture. Steaming timber removes much of the resinous matter, as evidenced by the discharge from the blow-off of a treating cylinder, so that the weight of the materials other than water remaining in the timber is not so much as before. Fur-

thermore, the fact that a piece of timber, an adjacent section of which has been steamed and then reduced to the same moisture content, is stronger than the steamed portion, is not infallible evidence of damage by the steaming process. Steaming removes the saps and resins from the cells and probably increases the moisture of the cell walls—the very moisture which affects the strength so much. In previous investigations as to strength, did the investigators ascertain that the percentage of moisture remaining in the *cell walls* was the same?

The conclusions to be drawn from experience are that the limit of allowable steam pressure, at least under 75 pounds, can not be set unless the conditions existing are known and a stated method of applying and cutting off of the steam is given. It is evident that the percentage of moisture in the timber, on being drawn into the cylinder, will affect the allowable pressure. Of the piling furnished by three plants for one job, two supplying the same timber, some partly seasoned, some reeking with sap, some steamed not over 30 pounds, that steamed at 60 pounds pressure continuously for ten hours and at lower pressures for an additional ten hours, showed the best under the pile hammer. One of the examples of well-treated paving blocks cited in the Yellow Pine Manufacturers' Association pamphlet on that subject, was subjected to a steam pressure of 80 pounds, corresponding to a temperature of 312° F. These cases are cited to show that high temperatures are not greatly detrimental to the timber, but that it is the wrongful application of such temperatures that cause the damage.

The final conclusion is that the specifications should not limit the steaming, but should leave this process to the judgment of the plant management, reserving the right, of course, to reject any damaged material.

VACUUM

Perhaps no part of the treating process varies so much as the application of the vacuum and, among engineers generally, there is no part of this process so little understood. Commonly, it is thought to remove the enclosed liquids by releasing the pressure and allowing them to flow out, but this part performed by the vacuum process is secondary, to say the least, and if this were all the vacuum was applied for it might be omitted in a majority of cases.

The steaming process tends to convert the moisture into steam, leaving, at the end of thorough steaming, the cells filled with steam

instead of water as originally. Theoretically, on the release of pressure the steam contained in the cells would expand and establish an equilibrium. The cooling of the timber after the release of pressure would cause a condensation of the steam within the cells. This theoretical condition is true to a limited extent. Some of the steam does necessarily escape by expansion, but that part is on the timber surface. The fall in temperature coincident with the release of pressure causes the condensation of the vaporized moisture and consequent filling of a ring of cells which would tend to retain the pressure on the interior of the timber. It is evident therefore that the temperature in the cylinder during this process should be kept high by means of the steam coil to counteract condensation. The fall of temperature evidently can not extend very far into the timber, owing to the relatively poor conductivity of wood fiber. Consequently, we have after the release of steam pressure, the outer cells empty or nearly so; within this merges a ring of cells completely filled with condensed moisture which forms a barrier to the escape of the steam from within. The application of a vacuum, reducing still further the exterior pressure, allows the escape of the previously condensed steam by allowing a relative increase of the pressure from within. This moisture, together with that which condenses on the exterior of the timber and is collected in the bottom of the cylinder, is a relatively small portion of the total extracted from a water soaked or sappy timber—amounting to about 4 or 5 per cent in the instances investigated by the writer.

It is physically impossible to extract by a vacuum the liquids from a piece of timber which does not contain a quantity of air in the cells, as there must be some medium within to expand and force the liquids out. This is the basis of the Lowery and the Rueping patents for the empty cell processes, the former relying on the air ordinarily contained in the timber to expand under the released pressure of the vacuum, and in the latter the expansion is had by the release of the compressed air injected into the timber previously. The amount of oil to be recovered by a vacuum after the oil injection in the full cell process is a very small percentage of the total injected.

It would be safe to assume that the use of a vacuum is important in the lighter treatment, and yet more important in the treatment of timber without steaming, and where a uniform and deep penetration is desired.

The practice in applying the vacuum is extremely varied, even

for the same conditions, at different works. A variation in practice from one-half hour to six hours has been noted in the experience of the writer on work almost identical in character. Such a variation can only denote an ignorance of the real time required. The proper length of time to maintain the vacuum must vary with the extent of steaming previously given and the degree of dryness desired before the injection of the oil. If the timber is air-seasoned and no steam applied the time should be relatively short, as only the air contained in the cells is to be withdrawn, but in the case of steamed timber time must be given so that the pressure from within may force out the collected moisture in the outer cells.

On account of the decreased pressure, the evaporation from the timber surface is very rapid and, consequently, if the vacuum is maintained for a long period, much moisture is extracted and exhausted through the vacuum pump; but unless the quantity of oil proposed to be injected is very large, the time employed in this manner is needlessly extended.

It is evident from the above discussion that no specified time can be set as proper for any treatment or any timber, but would depend on the condition of the charge and the extent of treatment proposed.

The extent of the vacuum as to the height of barometer is not so varied and usually depends on the character of the machinery, the tightness of the cylinder, and last, but principally, on the location of the gauge. There is but one proper place for the vacuum gauge —on the cylinder, removed from the vacuum outlet pipe. The practice of placing the gauge on the pump, or on any pipe line to the pump is exceedingly deceiving and accounts for the high vacuum attained at many works in a short space of time. The writer has yet to see the vacuums of 28 inches which have been reported from time to time as in use.

It is not sufficient that a vacuum of 18 inches, or any other specified vacuum, be attained, but after this vacuum is attained it must not be lost. The uneven penetrations so frequently noted are not caused by lack of rapidity in filling the cylinder with oil when the application of the oil extends over even twenty or thirty minutes. The application of an 18 inch vacuum represents the extraction of about three-fifths of the air contained in the treating cylinder, consequently, if this is not maintained after the filling with oil is begun, when three-fifths of the cylinder space is filled with oil the pressure on the upper portion of the cylinder is normal and

any further filling causes a pressure. What is the profit to extract the air (and gases) from the lower timbers to allow the infiltration of the oil if this air, etc., is to be gradually compressed into the timber in the upper tiers of the cages?

In those cases when the best results were desired, especially with treatment of 12 or 14 pounds, it has been the practice of the writer to maintain the even vacuum during the filling process, even though the oil had to be admitted slowly or stopped for a while to regain the maximum vacuum. This practice has eliminated the poor penetration generally evident in the upper tiers of timbers.

The practice of alternating steaming and vacuum several times before the application of oil has never appealed to the writer as an economical one. The time required for alternating a steam pressure and the time for exhausting the cylinder, after the pressure has been held a sufficient time, seems to more than overcome any advantage which might be gained by the process.

INJECTION

The final process of treatment is the simplest of the processes of creosoting timber and yet is the process in which the interests of the purchaser are, in a majority of cases, most concerned. The condition of the timber as to strength can usually be seen sufficiently for practical purposes after treatment, but the quantity and quality of creosote contained can only be approximated, even by the most scientific analysis of the timber. The variation of the quantity of creosote contained in the different sticks of the same charge and the variation of the quantity, even in the two ends of the same piece, make any test as to quantity averaging in the entire charge a rather wide guess. The quantity of creosote contained in a single piece of timber may, of course, be ascertained very closely by extracting the oil contained in a section or several sections, but this method is rather expensive and laborious for any large quantity. The depth of penetration may be deceiving. The condition of seasoning and the condition of treating influence penetration to a great extent. If the timber is seasoned thoroughly the percentage of oil contained may be 50 per cent or more greater than in a partially seasoned specimen. As heretofore mentioned, the creosote, ordinarily at least, enters the cell spaces only and it is held by many that the creosote never does penetrate the cell walls.

If this really is the case it is rather peculiar, inasmuch as the cell walls will give up and take in water any number of times and

yet have such an aversion to substance like creosote. Without doubt, the cells walls do not contain creosote to any great extent immediately after the injection, especially in the instance of steamed timber, but it is the opinion of the writer, borne out to a limited extent by experiment and examination, that creosote is present in the cell walls after the escape of the moisture from that portion. Immediately after treatment there occurs a seasoning of the treated wood, during which it loses weight to a marked degree, even at low temperatures. The surface becomes dry and, in time, the interior does not show nearly so much ''bleeding'' when cut or pressed with a knife blade. Evidently some oil has been volatilized, but the loss is principally water. The loss during the first three days exposure after treatment from a piece of 1 inch plank exposed in the shade to a maximum temperature of 75 degrees, amounted to nearly 15 per cent of the entire weight of the injected creosote. Evidently this loss was nearly all water, as the creosote was rather heavy and would not volatilize so rapidly.

If after such a loss of moisture, which must necessarily come principally from the cell walls, the creosote is liquid, as will be the case when exposed out-doors to temperatures above 100° F., it is the opinion of the writer that the creosote will penetrate the material of the cell walls just as water has penetrated in water-logged timber.

Creosote, being an oil, has no affinity for water, and if mixed there will be a separation with well marked strata of creosote and water. While this is a fact in experiment, it is not so in actual practice where other elements than water and creosote are present to emulsify the mixture and prevent a separation by sedimentation. Water, saps, and resins are present in the cells of steamed timber, and physically or otherwise mix with the creosote during the injection process, adding to the volume and causing a deeper penetration than in the case of timber seasoned by a process lacking in moisture, provided, of course, that the cells of both specimens are opened for this reception of the creosote.

For very light treatments—say those of 10 pounds or under—the absorption often becomes so rapid that the cylinder is barely filled before the required amount is absorbed. In fact, it has often been noticed that the timbers on top of the cage never were covered, the absorption being so rapid that the cylinder is never filled and no pressure applied. Where this is the case it would seem that the cheaper, open tank process would serve the same purpose, if a full

cell process is desired, or, better yet, the empty cell process—namely, Rueping or Lowery.

The use of less than 10 pounds of creosote per cubic foot of timber in the full cell process does not seem to the writer to be worthy of consideration for any timber coming into contact with the earth or exposed to any other chance for rapid decay. The lack of penetration on the heart side of sawn timber and the lack of penetration of entire sticks exposes them, as compared with the general average, to premature decay. If the vacuum is dispensed with entirely in these cases, it will be found that a deeper penetration is to be had approaching, in a much smaller degree, the Rueping process, in which the vacuum is not only dispensed with, but replaced by the injection of compressed air into the cells which, on the release of pressure after injection of the creosote, expands and forces out a large portion of the creosote.

The arrangement of pipes, valves, tanks, and cylinders at most creosoting works is a veritable labyrinth. Some of the arrangements are so cumbersome and unnecessarily complicated that it would seem that the management had determined on such complication to baffle inspectors and put oil into other places than the supposed one. This is probably not the case, but suffering from a reputation of crookedness given the entire business by a few individuals, it would seem to the interest of the reputable company to go to considerable trouble and expense to arrange the piping and valves so that an inspector could see what was actually going on, as well as to protect themselves from loss by leaking valves and pipes underneath the ground.

It is simple enough to figure the quantity of creosote taken from a tank, but to figure where that creosote has gone is another problem. Inspectors are paid to see what goes on and not to be the recipients of such information as the plant management sees fit to give them. Regardless of the honesty of the operators, it is the duty of the inspectors to see and check every movement of the oil and personally ascertain, if possible, any other fact bearing on the case. Unfortunately, inspectors are sometimes looked on as intruders and all information is grudgingly given.

The quality, as well as quantity, of creosote should receive attention during the injection or immediately prior thereto. A minimum specification having been decided on, it is the duty of the inspector to see that that quality is actually being used. The practice in paving block business of submitting a scientifically pre-

pared and costly sample for analysis and then treating with a commercial product should be eliminated, first, by the adoption of a reasonable specification and, finally, by the employment of an inspector who knows the business and attends to it in a proper manner.

Without a special reason the filling of the cylinder should not be made faster than the vacuum pump will extract the air and gases, for the reasons before given. The quantity absorbed will vary greatly and can in no case be more than approximated. With the proper arrangement of gauges, thermometers, etc., it is possible to compute, fairly closely, the amount absorbed after the cylinder has been filled. It may amount to as much as 8 pounds per cubic foot of timber in some cases, and for two charges of the same class of timber handled in very much the same manner, may vary 50 per cent—consequently, any figure on the total amount absorbed based on an assumed absorption is the veriest guess.

The rapidity of absorption with or without pressure depends to a marked degree on the temperature of the creosote; as a rule, the higher the temperature of the creosote the more rapid the absorption. Incidentally, there is another reason for high temperature in the oil, as the loss of water incident to the heating of the oil in preparation for the treatment usually will guarantee a small percentage of water in the oil at the time of treatment. It is hardly probable that the timber can be damaged by excessive pressure during the injection, as the absorption is too rapid to attain much pressure on the empty cells. The pressure used depends on the state of seasoning of the timber and the quantity of oil to be injected. Often it will not reach over 25 pounds, while in the heavier treatments it is the limit the cylinder is capable of withstanding, and that held for many hours.

The absorption at first is very rapid and may continue rapid until the sapwood is completely filled, after which it abruptly drops and continues very slowly. The time necessary to inject a certain quantity of creosote can not be foretold with any degree of precision and may vary 100 per cent with timber seemingly identical in structure and seasoning.

If the time of injection is to be prolonged the oil should be heated by means of the steam coils, for the double purpose of keeping the oil liquid and retaining as much heat in the timber as possible, so that the cell openings and cells may be kept open.

A few years ago it was commonly supposed that the heartwood

of the closer grained timber could not be penetrated, but it has been demonstrated that it is capable of absorbing, when properly handled, almost as much oil as the coarse grained or sapwood. It is merely a question of proper preparation during the seasoning process. In sawn timber, however, the penetration of the heart faces is so much less than the sap faces that in the lighter treatments it frequently causes weak places in the protection. The greater natural resistance to decay of the heartwood in a great measure remedies this fault.

After the injection is completed, it is not possible to withdraw any quantity of oil by means of a vacuum unless the vacuum process was omitted and air is contained in the timber. It is well, however, to withdraw the charge as soon as possible, or else chill the timber by means of air so that the oil may partially coagulate and prevent dripping.

Seasoning of treated timber by exposure to air is beneficial in may cases, as it allows the vaporization of the lighter oils and consequent crystallization of the oil remaining. Otherwise, if the timber is placed in contact with the ground, those light oils may keep the creosote liquid enough to flow out in considerable quantities. This is especially true in the case of ties.

FLUCTUATIONS OF WATER LEVEL IN A CANAL CAUSED BY THE FILLING OF LOCKS

BY

MR. LOUIS C. SABIN
Assistant Engineer

The two locks now in operation at St. Marys Falls Canal, Mich., are located side by side, connecting with the same channel. The Weitzel Lock is 80 feet wide in the chamber, 60 feet at the gates, and the length between hollow quoins of the service gates is 515 feet. The Poe Lock is 100 feet wide throughout, and 800 feet in length between hollow quoins of service gates. The lift is, ordinarily, about 19 feet. The locks are filled by culverts under the floor, closed by butterfly valves under the upper miter wall; the culverts are 8 by 8 feet in size, and the valves 8 by 10 feet, giving a clear opening at the valve of about 8 by 8½ feet. There are two culverts in the Weitzel Lock and six in the Poe Lock.

The upper reach of the canal is about a mile in length from its junction with the river to the head of the locks. It was excavated in earth and rock to a depth of 25 feet below low water, the rock sides being left rough and the canal face above the rock being formed of timber cribs. In the work of widening the canal, recently completed, the rock along the north side was channeled and concrete revetment walls built on top of the rock throughout the greater part of the length, only the upper end of the north wall being of timber crib construction.

When the valves are opened to fill one or both of the locks the water level in the canal above the gates is depressed, the extent of the lowering depending upon the number of valves opened. This depression of the water surface at the lower end sets up a current in the canal, which continues to flow downstream until the surface above the lock is about as far above the normal level as it had been depressed below the normal by the sudden opening of the valves. The current then starts back upstream, resulting in again lowering the water in the canal. If the water is not disturbed by again opening the valves, these fluctuations of the water surface

continue, with great regularity, for some time after the valves are closed.

Under conditions formerly existing, the changes in velocity and the reversal of the direction of flow in the canal made navigation difficult and unsafe, especially in view of the fact that the boats must pass in and out through one opening having a width of only about 108 feet. To remedy this condition, as well as to give additional room for navigation, the canal has recently been widened, and the effect of this increase in cross-section upon the currents and fluctuations in water levels has been determined.

A sketch plan of the canal is shown on Plate I. The full line shows the present outlines of the canal, while the dotted line shows the northern limit as it existed prior to the widening.

The fluctuations of water level in the canal caused by filling the locks are shown in Plates II and III. The increase in amplitude of the fluctuations, as the number of valves opened is increased, is brought out in Plate II, where the rate of filling the Poe Lock is also shown in some cases. It may be said, however, that the amplitude does not depend, alone, upon the number of valves opened, but also upon the phase of the wave, or the condition of the water level, whether rising or falling, at the time the valves are opened; in other words, to open four valves when the water level has begun to fall may cause a greater fluctuation than to open six valves when the water level is rising. If the valves were always opened at a time when the water level is constant, the effect of the number of valves on the amplitude of fluctuation would be more clearly brought out, but the locks are seldom out of use long enough to permit the water in the canal to come to rest. The observations on Plate III indicate the decrease in amplitude with the increase in distance from the locks, the fluctuations becoming practically nil at the upper end of the canal where it joins the river. It will be noticed that the rise or fall at the different points along the canal is almost simultaneous, and that the time length of the wave, or the interval between two successive high water stages, is practically constant at twelve to thirteen minutes, without regard to the number of valves opened. Part of the observations shown on Plate III were made prior, and part subsequent, to the widening of the canal, and the effect of the enlargement of the channel upon the character of the fluctuations may thus be seen. It appears that after the widening the time between two successive high water stages remains the same as before, but the amplitude is considerably diminished.

PLATE I

ST. MARYS FALLS CANAL
SAULT STE. MARIE MICHIGAN
OUTLINE MAP
OF A PORTION OF
CANAL AND RIVER

The most important effect of the widening is the reduction in the velocity of the current in the restricted section of the canal, as it is this, rather than the rise and fall of the surface, that interferes with navigation. By considering the amount of water drawn off into the lock, and the amount required to fill the canal from a low stage to a higher one, the velocity of the current through the restricted section may be obtained.

Comparing in this way the flow through the restricted section at 700 E. (see Plate I) for five minutes (10.22-10.27 a. m., November 20, 1903) with that for five minutes (11.24-11.29 a. m., October 18, 1910), while the Pce Lock was being filled with six valves in both cases, the following results are obtained:

During five minutes.	November 20, 1903. Before widening canal	October 18, 1910. After widening canal
Water used in filling lock .... cubic feet..	486,000	810,000
Water stored in canal .... cubic feet..	1,736,000	1,061,000
	2,222,000	1,871,000
Cross-sectional area for same water level .... square feet..	2,800	5,600
Resulting mean velocity at restricted section .... feet per second..	2.65	1.12

The following conclusions may be drawn from the observations:

The fluctuations caused by the filling of the locks, before the widening of the canal had an amplitude of 2½ to 5 feet.

The time interval between successive high water stages is twelve to thirteen minutes.

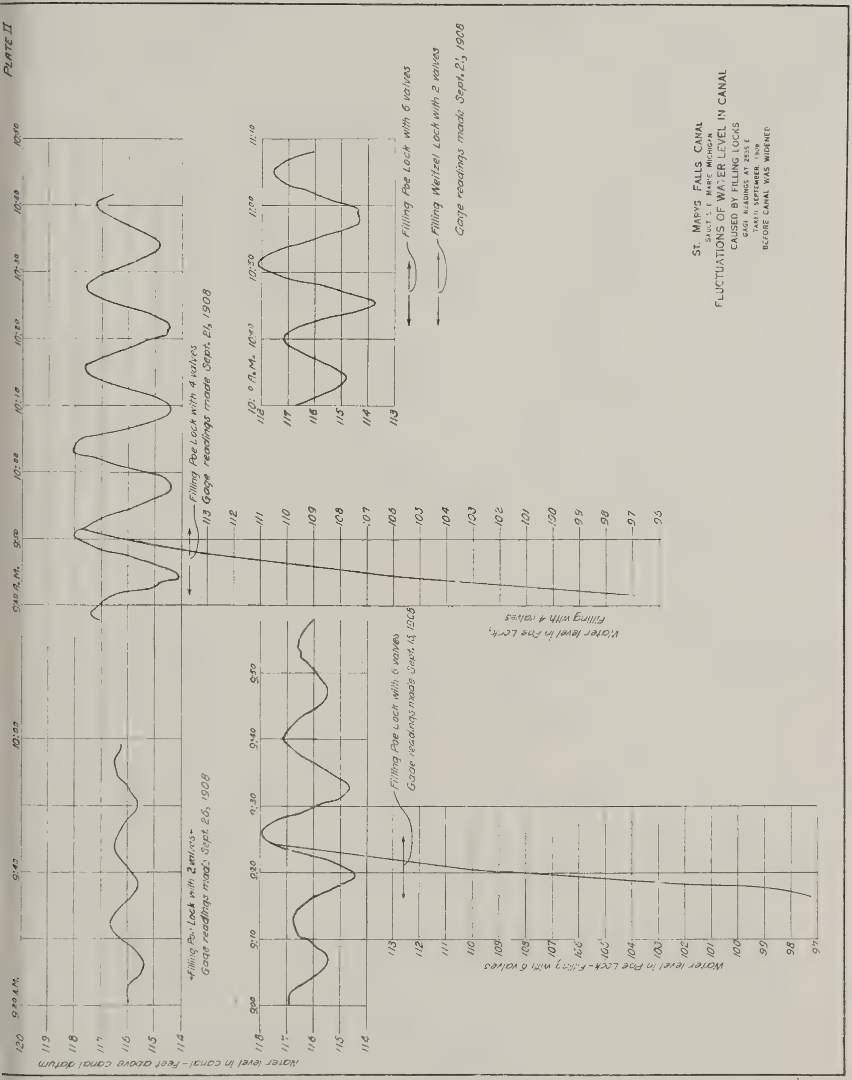
From one to two hours time is required for the water in the canal to come to rest after an initial disturbance of considerable magnitude.

The amplitude of the fluctuations depends upon the number of valves opened, the sign of the change in stage of water in the canal at the time of opening the valves—that is, whether rising or falling—and on the cross-section of the canal.

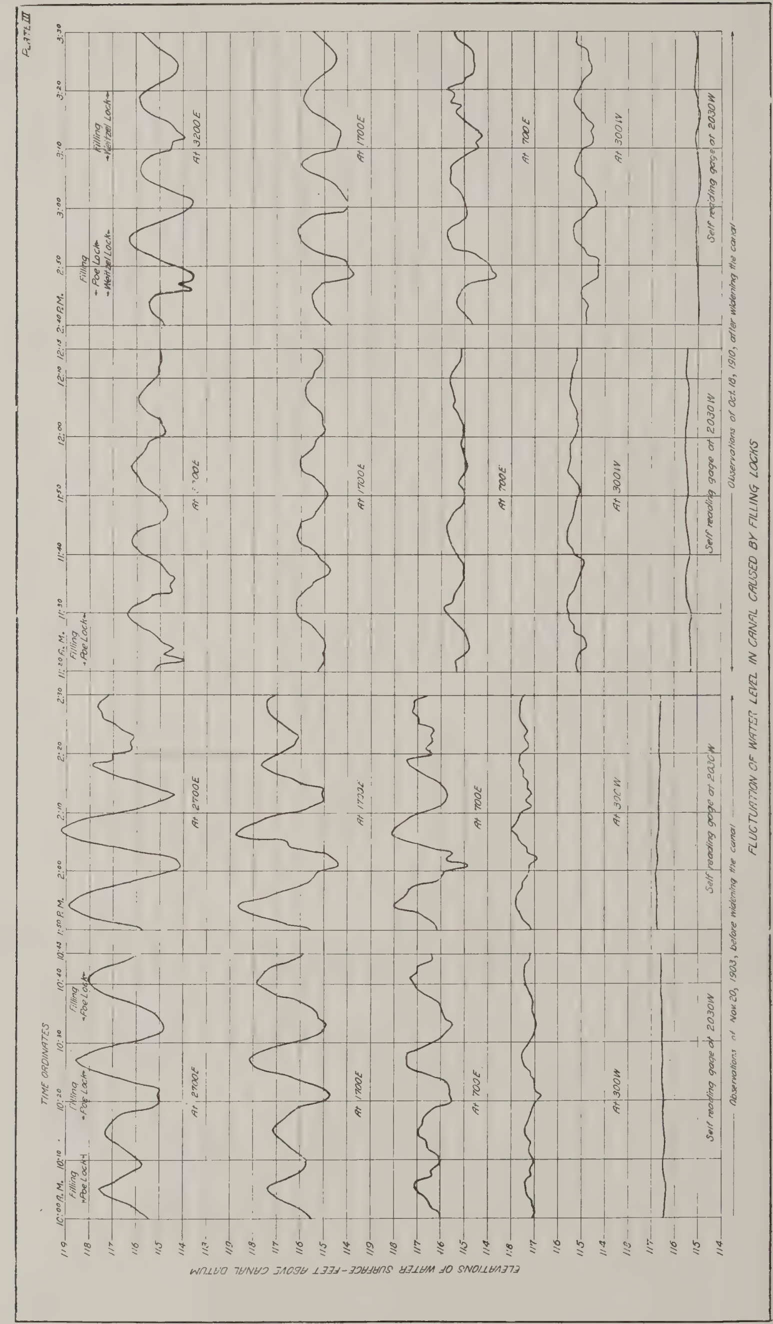
The water level reaches the highest stage at nearly the same time throughout the length of the canal, but the amplitude decreases gradually from the locks to the entrance, being nearly zero at the latter point.

The enlargement of the canal reduced the amplitude of the fluctuations by about 50 per cent, and the velocity at the restricted section by about 60 per cent, but had no effect on the time interval between successive high stages.

PLATE II



ST. MARYS FALLS CANAL
SAULT S. E. MARIE MICHIGAN
FLUCTUATIONS OF WATER LEVEL IN CANAL
CAUSED BY FILLING LOCKS
GAGE READINGS AT 2535 E
TAKEN SEPTEMBER, 1908
BEFORE CANAL WAS WIDENED



Observations of Nov. 20, 1903, before widening the canal

Observations of Oct. 18, 1910, after widening the canal

FLUCTUATION OF WATER LEVEL IN CANAL CAUSED BY FILLING LOCKS

UNDERGROUND CONDUIT CONSTRUCTION*

BY

Mr. D. A. HARRINGTON
*Consulting and Supervising
Engineer*

The subject on which I am to speak this evening, though probably more or less familiar to most of you, is a comparatively modern branch of engineering.

If one could have looked beneath the pavement of our cities only thirty years ago, there would have been found among the network of water and gas pipes and sewers only an occasional modest sample of electric conduit.

But during its short life this infant has been nurtured by many trained minds and fed with millions of dollars of capital, and under these inspiring influences it has grown and flourished to a remarkable degree.

We may now find the conduit for electric wires elbowing its way among its companions beneath the pavements in every part of our cities, and making great strides of 20, 50, and 100 miles from one city to another, so that to-day it claims a place in the front rank of distributing mediums in point of scope, utility, and commercial importance.

Practical underground conduits were first constructed in this country about thirty-five years ago, and since that time the growth has been steady and very rapid. All of our large cities are now practically honeycombed with pipes for electric wires, and at the present time it would seem impossible to do business without them.

There are two main divisions of conduit systems, the solid systems and the drawing-in systems.

A solid system is one in which the wires or conductors are laid in some insulating compound in pipes or boxes, the joints made and the work completed while the trenches are open. This system has been extensively used for electric light and power, and to some extent for telephone and telegraph purposes. It has the especial ad-

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*Lecture delivered at the Engineer School, January 18, 1911.

vantages of flexibility in construction, as it can be laid with bends, curves and square corners as well as straight lines. The varying lines of the highways and by-ways can be easily followed and obstructions in the streets avoided, while at the same time it can be laid comparatively near the surface of the streets. This system has been used principally for local distribution.

The disadvantages of this system are, first, that in many cases the original economy of construction is curtailed by the excessive number and size of wires placed to provide for possible future necessities, and, second, that in case of the failure of any conductor on account of mechanical or electrical injury, the conduit must be uncovered and the insulation removed in order to make repairs, and in case of additional wires being required, practically the entire process of construction must be repeated in order to install such wires.

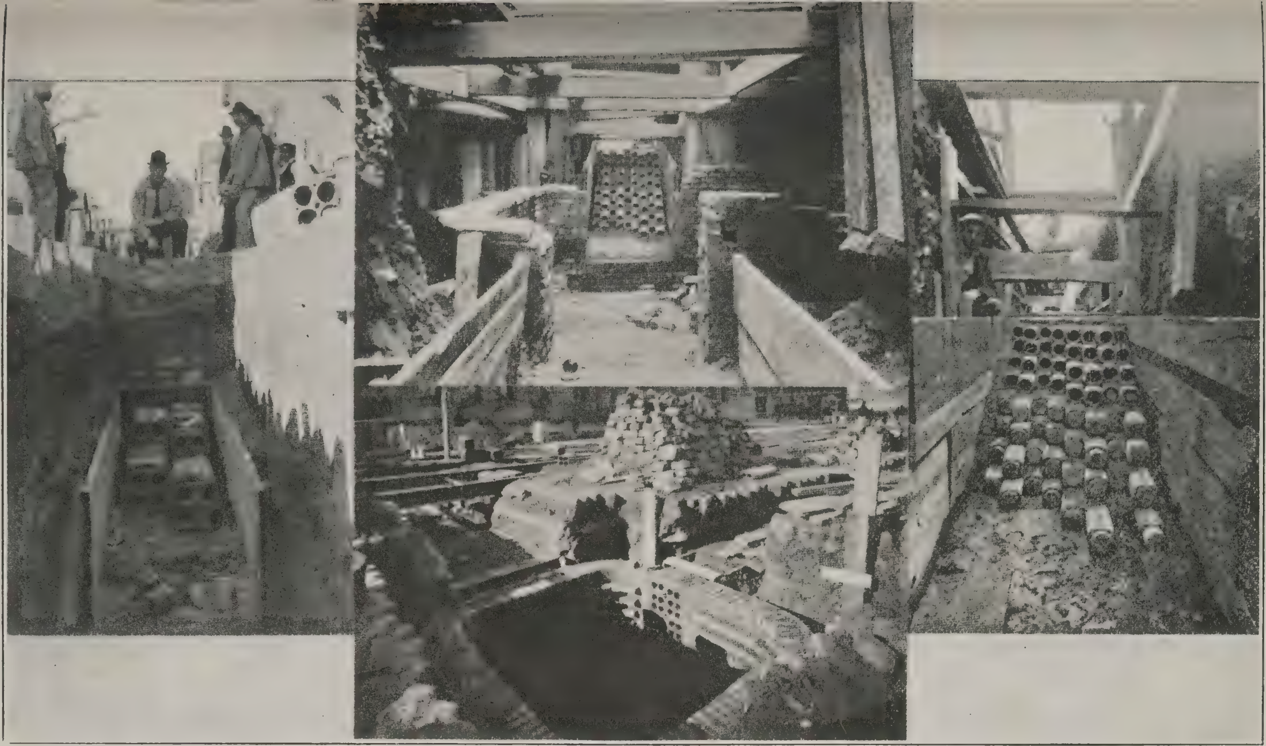
For a drawing-in system, manholes are built at convenient distances, trenches are opened between, and ducts are laid connecting one manhole with another; the trenches are then refilled, the surface of the ground restored, and at any convenient time the cables are drawn in and out of the ducts between the manholes and connected as desired.

The principal advantage and economy of this system is that only such cables as are needed are drawn in at first, and additions, changes, and repairs can be made as required without disturbing the surface of the ground.

This is a very important advantage because of the liability of defects developing in the conductors from various causes, because of the frequent calls from customers for different or additional service and because improved and more satisfactory conductors are constantly placed upon the market and better and more economical methods of operating the system are frequently devised; all of which conditions make it a distinct advantage and economy to be able to conveniently install, change, or repair conductors at any time of the year.

Many different materials have been used in the construction of drawing-in systems, the most popular being wood, cast-iron, wrought-iron, cement, and clay.

Wood, when used in the construction of conduits, is generally treated for preservation by kyanizing, vulcanizing, or creosoting; it has been used both in its natural state and as a pulp in the construction of single and mutiple ducts. Multiple ducts were first used, but of late years the single duct is most used.



Conduit of 72 Single Ducts entering Manhole

Vitrified Clay Conduit, 2 and 4 Duct Multiples

Manhole and Different Groupings of Multiple Duct

Conduit of 64 Single Ducts with Plain Ends

Fig. 1.

In making multiple duct wood conduits it has been customary to use 2-inch plank for the outside walls and inch boards for the interior partitions, these parts being framed together in 16-foot lengths; the sections are placed in the trench to line and grade, and the joints are wrapped with tar paper smeared with pitch and secured by nailing on cleats of inch boards; the whole is then further strengthened and protected by spiking 2-inch planks on top, so laid as to break joints with the sections of conduit. This makes a very firm, strong conduit, but its rigidity is an objection to its use in congested city streets on account of the difficulty of making curves and bends to avoid obstructions.

Single wood ducts have been made by boring a 3-inch hole lengthwise through a stick of spruce 4¼ inches square; they are furnished in 8-foot lengths with a few short lengths for convenience in use; each piece is fitted with tapered socket joints and the finished lengths are treated with creosote.

In building a conduit of this material the lengths are driven together in the trench in the number and grouping desired and a covering plank is laid on for protection.

A conduit of single wood ducts, protected simply by a covering plank, can probably be laid more rapidly and at less cost than one of any other material used, and it has been quite popular in suburban districts where a few ducts are needed and the development of business is not sufficiently advanced to enable the determination of the location and extent of permanent requirements.

A few years ago an underground system was designed in which the conduits and manholes were made of cast iron laid up in sections, with special fittings for making connections to buildings, poles, and lamps. This system had many good points in design, but the lines on which it could be laid were too rigid for convenient street construction and the material was comparatively fragile. Conduits of this material were installed in two or three cities; it did not become popular, however, and has not been used recently to any extent.

Wrought-iron pipe of heavy and standard weight, and the lighter well casing and boiler tubing have been used to a very large extent and by men of all degrees as receptacles for underground electric wires; there have been special machines made for bending the pipe on the work and special couplings for connecting bent pipe; with these accessories a wrought-iron pipe can be made into a very serviceable duct for wires along a crooked path, and consequently has

been very popular with engineers and contractors when considering the problem of building a conduit over, under, or around perplexing obstacles.

In the early days of conduit work, iron pipe was quite generally used even for the larger conduits, but of late years the comparatively high cost of the pipe with proper protection, and the fact that from an electrical standpoint an iron pipe underground is not a satisfactory receptacle for wires, have limited its general use to small lines or connections to buildings, poles, etc.

Cement-lined pipe consists of a cylindrical jacket of sheet iron, with a lining of cement and iron socket joints; it has been made in 8-foot lengths, can be laid very rapidly, and when carefully handled and properly covered with and separated by concrete, makes a strong and satisfactory conduit. It has been used very extensively. While the cement-lined pipe is not as flexible for use in conduit building as wrought-iron pipe, a very satisfactory curve can be made by cutting the pipe into short lengths and making a slight bend at each joint, and the round shape gives an advantage over the square duct in that by properly manipulating the round pipe in the concrete matrix, the grouping of ducts and shape of the conduit can be changed without breaking the continuity of the ducts. This is a great convenience at times in avoiding obstacles.

Vitrified clay conduits are made in single and multiple ducts. The single duct is round or square, with walls ½ to ¾ of an inch thick, and is made up in 18-inch lengths with socket joints or plain square ends.

In laying a conduit of this material, a concrete bed is prepared in the trench, and on this the sections of conduit are laid in the grouping desired, care being taken to have the sections in accurate line with each other and so arranged as to thoroughly break joints horizontally and vertically; each course of ducts is bedded in a thin layer of cement mortar.

The grouping of ducts is then covered on the sides and top with a layer of concrete. A covering of plank is generally laid on the top concrete to protect the conduit from mechanical injury.

Multiple-duct vitrified clay conduits are made, containing either two ducts, three ducts, four, six or nine ducts; the sides of the conduit and partitions are made from ½ inch to ¾ inch thick; the ducts are either square or round and from 2 inches to 4½ inches inside measurements.

These multiple ducts are made in sections from 2 feet to 6 feet

long, held in line by dowel pins, and are laid with or without a concrete envelope as the conditions require; in either case, however, the joints at least are wrapped with cloth, paper, or burlap, and covered with pitch or cement mortar. It is advisable to place a covering plank on this and all conduits laid in public streets.

The principal feature in favor of vitrified clay conduit is the cheapness of the material, but it has good points in which it equals more expensive materials and excels cheaper kinds, with the result that it has been very popular among those who have been buying conduit materials in large quantities.

Some of the good mechanical points of the duct made of vitrified clay are that it has a smooth inside surface, is practically permanent, is an insulator, and, if properly laid, is partially water and gas tight.

Objections to it are, the lack of proper joints and the short length of the sections, which increases the number of poor joints; its weight also is a factor of considerable extra expense in freight, teaming, and handling.

Wood fiber is used very successfully in the manufacture of pipes for carrying wires, made up in lengths of about 5 feet, with socket or sleeve joints or screw couplings; it is treated for permanency, is claimed to be water and acid proof and an insulator electrically. The price charged for this pipe has been until lately so high when compared with other material as to practically prohibit its use in general conduit work, but is now sold at a figure which compares quite favorably with other pipe and is being used extensively.

Conduits of wood fiber pipe are sometimes laid in the ground without concrete or other protection, but for important conduits the ducts should be laid in concrete, which separates the ducts and forms an envelope around the top, bottom, and sides. A covering plank should also be used to protect from mechanical injury.

The socket joint fiber duct has been most generally used, especially when laid in concrete, but the sleeve joint—which is machine fitted—is very satisfactory, and it is probable that it will become more popular.

Some of the good points of fiber duct are, that it is waterproof and an insulator, is made in lengths of 5 feet or more, has good joints so that water-tight work is quite feasible, and its light weight is an important factor in transportation and handling.

There have been several attempts made to manufacture a glass

pipe for use in underground conduits, and some excellent samples have been produced; but it has not been put to any general practical use.

It is interesting to note some of the radical changes in important details that have been made from time to time in the construction of underground conduits.

Some of the conduits laid twenty-five years ago were made of wrought-iron pipes with screw couplings, laid with a concrete envelope with manholes waterproofed so that the system was practically water-tight.

With increasing demands for conduits, ducts of cheaper materials and open joints were introduced and for several years the question of water-tight work was practically ignored; cables and apparatus have been so handled as to work safely in water and manholes have been drained to the sewers and pumped out when necessary.

Fig. 2. Conduit of Fiber Ducts in Concrete

During the past few years, because of troubles from electrolysis, because of the danger of the current from a defective cable connecting through an open joint in a duct to the cable in an adjoining duct, because of the desire to install more apparatus underground, and because for other general reasons it is inconvenient and expensive to have water leaking into the system, there has

again been a growing demand from operating engineers for conduits which can be made water-tight at reasonable expense.

This has brought the question of providing ducts with water-tight joints again into prominence as being the most practical method of making a tight conduit.

It is, of course, practicable to enclose the whole conduit in a waterproof blanket, and this has been done in some extreme cases; the process is, however, quite expensive, adding perhaps 50 per cent to the cost of the conduit, and considerable care is required to maintain this outside protection in a perfect condition.

Considering the ducts now principally used and their adaptability to meet the requirements mentioned, it seems unfortunate that while vitrified clay ducts have been manufactured for ten years or more there has been no important improvement in design or accuracy of the product and no attempt has been made to make tight joints.

It has been found impracticable to place a waterproof wrapping around each joint of the individual clay duct, so that if a conduit made of vitrified clay is required to be water-tight it must be provided with a waterproof blanket around the whole conduit.

It would seem that a clay duct more accurate in its lines and with closer fitting joints could be produced, and while this would perhaps add somewhat to the cost, an improvement in these details would undoubtedly make it more valuable for good construction.

The material and texture of the wood fiber ducts now on the market make them well adapted to being accurately cut and shaped by machine; this is especially true of those fiber ducts for which the material is accumulated into a homogeneous mass, and it is quite practicable to furnish these fiber ducts with tight-fitting joints.

The socket joints provided on fiber ducts are convenient for straight conduits under ordinary conditions, but are somewhat fragile and must be handled with care in matching and sealing the joints in order to make water-tight work; screw joints are satisfactorily made on the fiber ducts, are particularly convenient for some conditions, but are expensive and hardly practicable for general work.

The tapered sleeve joint lately furnished on some fiber ducts seems to be particularly adapted to conduit work; it is less delicate than the socket joint, more flexible than the screw, and

stronger than either; it is quite practicable to make good curves and water-tight work with this joint.

The demand of late years for very large quantities of duct has unfortunately led both purchasers and manufacturers in many cases to work for a cheap price rather than the quality of the duct.

The cost of the pipe or duct is generally only 10 to 15 per cent of the cost of the finished conduit, so that an increase or decrease of even 50 per cent in the cost of the duct would mean only a change of 5 per cent in the total cost of the conduit.

The fact that the duct is usually purchased in large quantities gives an undue prominence to a small per foot saving, and while the resulting percentage of saving on the whole conduit is very small, the defect in the duct, which is the vital part of the conduit, is a defect in the same degree to the whole conduit.

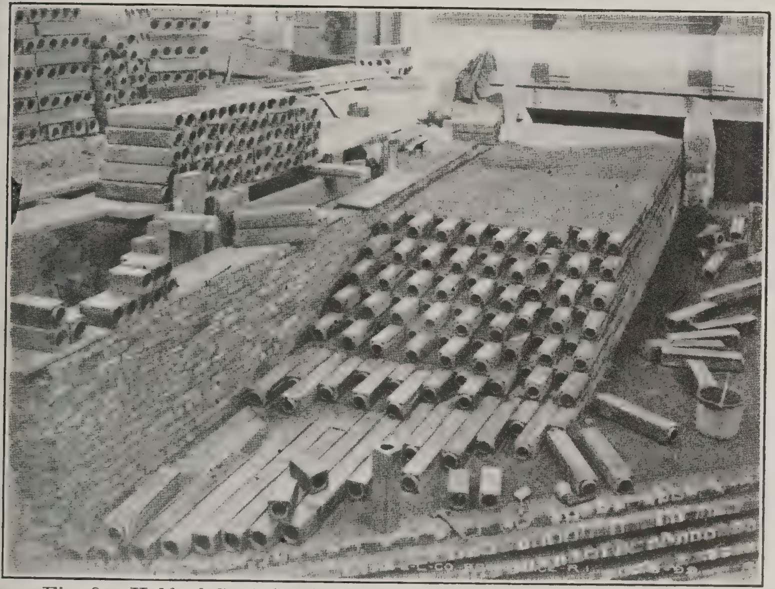


Fig. 3. Half of Conduit of 224 Single Clay Ducts with Socket Ends

In laying many of the ducts now furnished, we are dependent for good results on the skill, accuracy and faithfulness of the man who does the actual work of placing the ducts in position, and as the ducts when laid are of necessity covered so as to be out of sight almost immediately, there is a liability that poorly matched pieces, or pieces that have slipped out of position on the fresh mortar, will be overlooked; this has frequently happened in practice and has incurred an ultimate extra expense in operating

the conduit far in excess of the extra cost of a duct of better design and construction.

In the interest of good conduits it is a satisfaction to note a growing demand for ducts so designed that they can be easily placed and maintained in correct position in relation to each other.

A monolithic conduit has lately been designed and has been installed and operated to some extent. This system provides a continuous concrete conduit from manhole to manhole, the ducts being simply holes in the concrete.

The method of constructing this conduit is to prepare a trench and place in the trench at a manhole a hollow box of the size and shape of the conduit; this box is then drawn like a sled from one manhole to another and, as it proceeds, a sufficient quantity of concrete to form the conduit is poured into the box; as the box moves on, the concrete is left behind in the shape of a conduit. The holes for the ducts are formed by short steel tubes in the box and are maintained by long rubber or paper tubes inflated by water under pressure. When the concrete has hardened, the water is removed and the deflated tube drawn out of the ducts. A simple device has been designed for coating the interior of the ducts with waterproof compound.

This system, which is understood to be covered by patents, is certainly of interest and has many good points, but as the writer understands that the system is not now sufficiently perfected to be proposed for constructing large conduits, it would seem premature to discuss it at this time.

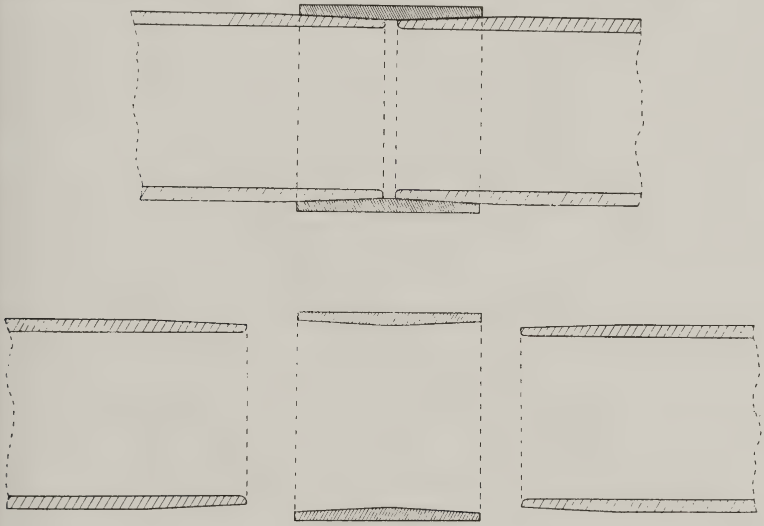
It is understood, however, that an adaptation of the system has been perfected for laying a conduit composed of thin fiber tubes enclosed in asphaltum concrete, to contain bare wires carrying current of low voltage.

Underground conduits may be used for the wires of electric railways, telegraph companies, telephone companies, or electric light and power companies, and while the same general style of conduit is adapted to the use of either, the requirements in details of distribution are quite different, and the nature of the service required must be considered in locating the conduit and determining the number, location, and size of manholes.

The layout of a distributing system for the feed wires of an electric railway is such as will provide a direct and convenient route for cables from the power station to certain fixed feed points on the line of the railway; no provision need be made for intermediate

distribution and the manholes are required only to be built of such a size and placed at such intervals as to provide for the convenient and proper handling of the cables.

A distributing system for telegraph wires is required principally to provide for trunk lines in and out of the cities, but the occasional lines run to private offices and the wires for messenger calls make it necessary to provide for reaching all important buildings, and for this purpose the conduit should be so located as to be accessible at practically all points in the business district, and the manholes should be so located as to conveniently connect from them to the required building.



TAPERED SLEEVE JOINT FOR FIBRE DUCT
Fig. 4.

The underground distributing system for the wires of a telephone company must provide for trunk lines in various directions, and also for connecting to individual buildings in all parts of the district; the problem in this case is considerably simplified by the fact that because the service required is all of the same character and the amount of current used is so very small, many wires for all the service in a locality may be bunched together in a small space and carried through or along the sides of buildings without danger to persons or property or detriment to the service.

In designing a conduit system to properly accommodate the

wires used to distribute the current from an electric light and power station, the conditions to be considered are much more complicated than those mentioned above. The conduits should be such as will properly contain and protect cables carrying heavy currents, and the manholes so equipped as to provide means of protecting the cables of various voltages from each other, and of such size and shape as to allow for the safe and proper handling of the cables and space for installing such junction boxes, transformers, etc., as may be required.

The local distribution of electric light and power wires is a matter on which engineers, electricians, and municipal and insurance officials have many opinions; it is a subject which should certainly be handled with care and intelligence.

In some cases the customers in the vicinity of the stations have been supplied by laying a solid system of tubes for low tension currents from the stations through the main streets and connecting directly with the buildings to be served.

In other cases, a combination of drawing-in system and solid system has been employed by sending low-tension current through cables in conduits from the station to certain determined points throughout the district, and there connecting to solid tube lines which carry the current to individual buildings.

Another method is to send high-tension current from the station through cables in conduits to points in the immediate vicinity of the customers to be served, and there transform to a voltage suitable for the work, and distribute the weaker current into the buildings. The transformers may be placed in manholes or vaults or on poles or buildings.

The current is also sent out from the station at from 500 to 3,000 volts or more, and used without transforming for power or lighting.

It is of great advantage to determine which of the above methods or what combination of them is to be used before laying out the conduit system, which can then be designed to suit the plan of distribution decided upon.

When an underground system is to be laid out, it is generally designed to take the place of an overhead distributing system, and in that case the plan is often to place only the main lines underground at first, to connect at convenient points to pole lines or house tops and continue the local overhead distribution. This is somewhat of a saving at first, but in practice the combination has generally been only temporarily continued and eventually the

thoroughly underground system with individual building connections has been adopted as tending to true economy and good service.

Having in mind the varied conditions as noted above that may arise, it is evident that in making the original design for a system of underground conduits for an electric light and power plant, due consideration should be given to the probability that there will be an ultimate demand for an entirely underground distributing system. This will often be a factor in choosing locations for conduits and manholes, and a reasonable extra expense is in some cases warranted in the original work in order to provide for probable future requirements.

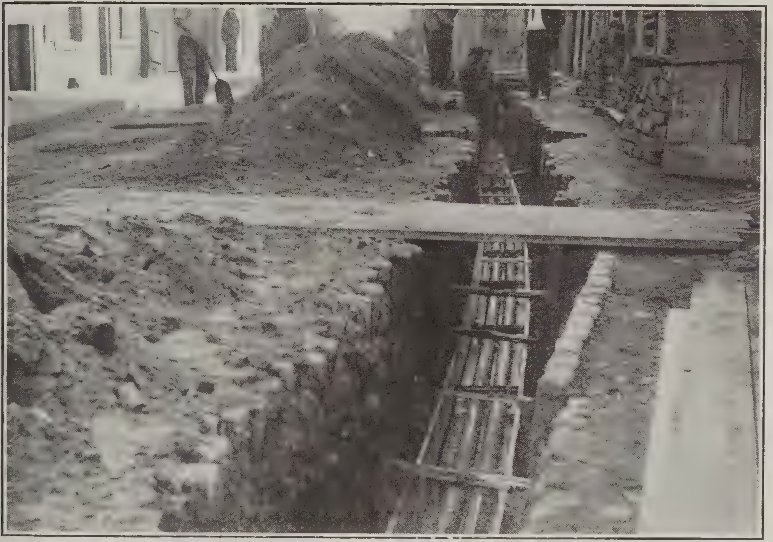


Fig. 5. Curved Conduit of Fiber Ducts

A scheme which is often proposed and sometimes finds favor with managers and engineers who desire to do thorough work, is to construct either one or two conduits in each street, separate from the main line, to be used only for local distribution; on these smaller conduits sub-manholes for taking off connections are located at regular intervals and connections are at once made to all buildings where service is, or may at any future time be, required.

This would seem to provide well for future business and preclude the necessity of any further excavation in the street—two important features in its favor and which make it in a few special cases an ideal system.

For use in the average city, however, this system is more ideal than practicable; the discrepancy between the possibilities which must be provided for in such a system and the use that is actually made of the facilities provided is so great that the cost figures out of all proportion to the probable benefit to be derived.

A satisfactory and ultimately economical method of handling local distribution is to thoroughly investigate the buildings in a district to determine the definite locations for connections required for present business before the conduit is built; the manholes and sub-manholes are then laid out so as to connect economically and satisfactorily with the points of entrance determined upon and also to provide in a general way for reaching in the future all other buildings and vacant lots in the district.

With the manholes and connections thus thoroughly planned, it is generally practicable to lay portions of many connections in the same trench with the conduit and also to place considerable lengths of two or three connections in one trench apart from the conduit.

This method of utilizing the trenches is an economy in construction and also caters to the public sentiment in favor of doing all work in a street at practically the same time.

It is at times considered very desirable to construct a common conduit system for the wires of two or more companies, in the interest of economy and to avoid the inconvenience of constructing parallel lines in the same street. If the work is laid out and constructed without proper consideration and care, there is great chance for trouble from such a combination, but if the use each company is to make of the system is intelligently considered in designing the conduit and locating the manholes, and the proper extra care taken in construction because of the peculiar nature of the work, it is perfectly feasible to construct an underground conduit system which shall be satisfactory for the use of two or three companies.

The number, location, and size of manholes to be built is governed by the requirements of the system and local conditions; it is possible to properly operate a conduit with stretches of 700 to 800 feet between manholes, but it is considered best to limit the distance to about 400 feet where practicable, and manholes may be placed as often as is necessary to meet the local conditions.

Manholes should be located at the low points in the grade, if

practicable, as it is an advantage to have all parts of the conduit system drain to the manholes.

There must be a manhole at each point where two conduits intersect, and others are located at convenient points for making connections to buildings, etc.

The minimum practical size for a main line manhole is about 3.5 by 4 by 5 feet deep, and should be limited to conduits of four ducts, or less.

A manhole 5 by 6 by 7 feet deep is considered satisfactory for a conduit of eight ducts, one 5 by 8 by 8 feet deep for sixteen ducts, and one 8 feet square and 10 feet deep will serve for thirty to forty ducts.

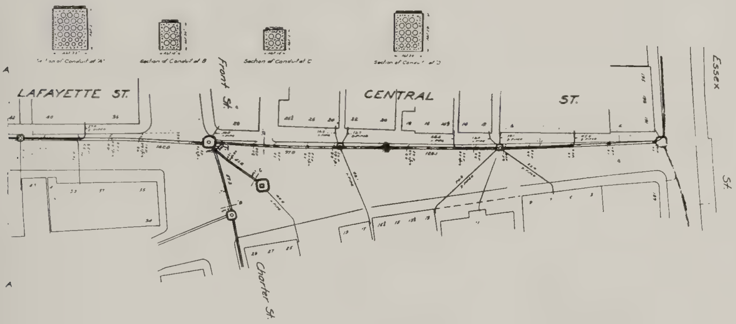


Fig. 6. Layout of Conduit and Connections

The kind of service to be performed and the character of the current to be used should both be factors in determining the size of the manholes, and when apparatus other than cable is to be installed in a manhole its dimensions should be increased for that purpose, so that the space for handling cables will not be reduced

When underground transformers are used, it is advisable to place them in special manholes off the main line rather than in main line manholes; this leaves the much needed space in the main manholes for conveniently and safely handling and arranging the cables and does not add materially to the expense.

Manholes are made with walls of brick masonry and concrete; the tops are of stone slabs or brick masonry supported by steel beams, or of reinforced concrete, with iron frames and covers.

In the suburban districts where many manholes of the same size and shape are to be constructed the use of concrete has become quite popular, but in the congested streets of the cities, on account

of the peculiar shapes often required and general lack of similarity between manholes, nearly all have been built of brick masonry.

In designing the iron frame and cover, the circular shape has a distinct advantage over the square in that that square cover may fall into the hole to the detriment of the cables, while with the round cover this is impossible.

In determining the size of conduits to be built in various systems, there has been a tendency to economize unduly in the number of ducts, particularly in the conduits of smaller size. It has been proved in many years' practice that it is wise foresight to have one or two spare ducts throughout the system, and the unequally proportionate cost of conduits of different size should be considered in fixing the number of ducts for any part of a system.

The cost of installing conduit of different sizes, including manholes, using either fiber or clay ducts and first-class construction generally should be under present conditions about as follows per conduit foot: two ducts, $1.50; four ducts, $1.90; eight ducts, $2.60; twelve ducts, $3.10; sixteen ducts, $3.60; twenty ducts, $4.00, and forty ducts, $6.50.

There is a growing demand for some type of underground construction satisfactory for use in the residential and outlying districts where the expense of a first-class conduit is prohibitive, considering the small amount of business to be provided for.

In such a district, and especially in streets where only a few local wires are required, two or four clay or fiber ducts may be laid in the ground without a concrete envelope and with or without cement or asphaltum joints, as conditions require.

These ducts, when laid in the street, should always be covered by plank or other strong material, to distribute the street load and protect the ducts from mechanical injury.

A conduit of this style can be laid near the surface of the ground and so require only comparatively small and inexpensive manholes; the cost of such a conduit is usually not more than 50 per cent of the cost of a first-class conduit with concrete envelope.

It is advisable to prepare plans containing all information obtainable in regard to streets where conduits are to be built in the congested portions of cities.

In the smaller cities and suburban districts some engineers of experience prefer to dispense with detail plans and to be guided by advance investigation at the time of building the conduit.

This may be at times a wise policy, but on general principles it is safe to maintain that the money expended in plans intelligently made is well spent, and the information obtained, however meager, is well worth what it costs.

The preliminary plans of city streets may show gas and water pipes, sewers, pneumatic tubes, electric conduits, heating conduits, sidewalk lines and areas, subways, car tracks, and cross-walks.

It is also well to note the grades of the street surface and of underground structures when possible.

These plans, in order to be reasonably reliable, should be made by or under the immediate supervision of one who is well informed in regard to the structures to be found underground and the details of their construction.

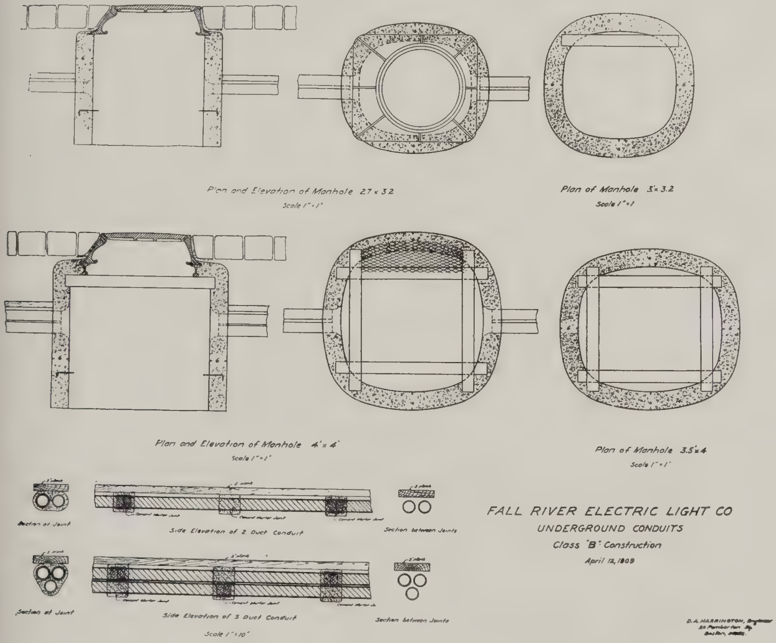


Fig. 7. Distributing Conduit and Manholes

In some cities the location for the conduit in the street is designated by a city official, but usually the engineer in charge of the work submits a proposed location to be approved by municipal authorities.

The determining of this location is an important matter and one to which the engineer may well give careful consideration, as

an error of judgment in this detail is likely to be expensive and may lead to a permanent defect in the system.

A conduit should, when practicable, be laid to a straight line and grade; this is especially desirable where the ducts are to be well filled with cables, or long distances between manholes are required.

A curve of reasonable radius is not a serious objection where the length between manholes is short, but bends or sharp curves are objectionable at any point in the system and should be avoided.

The question of drainage and ventilation of the conduit system may well be considered together, because the usual method of drainage by connecting the manholes with sewers makes a reason for ventilation, and the popular method of providing ventilation by perforating the manhole covers creates an additional demand for drainage.

The opinions of engineers vary to a very wide degree in regard to the advisability and necessity of draining and ventilating manholes.

In one or two localities all manholes have been equipped with drains and a pipe run into each manhole to supply air under pressure; openings in the pipe in the manholes were so regulated as to produce a pressure of air in the manholes slightly in excess of the pressure of gas in the ground adjacent. This system is effective, but expensive and not generally warranted.

In some systems all manholes are supplied with drains and all covers perforated, with the idea that whatever gas or water comes in one way will go out the other.

A method of dealing with the matter which has been tried with success in several cities is to make all manholes reasonably tight, waterproofing when necessary, provide against gas by plastering the manhole walls thoroughly and closing all ducts at the manholes, and, by a tight inside cover, prevent the water from coming in from the street. In this way the manholes are practically isolated from the surrounding soil and from each other, and leakage of water or gas will be so small as to give little trouble.

The closing up of ducts between manholes prevents the spread of gas or water from one to another and in case of gas, especially, this greatly facilitates locating a leak.

This method of sealing the manholes up from outside influences is quite an advantage over having gas and water, and sometimes steam and sewage, pass in and out of the system.

In constructing a conduit of either of the materials or designs mentioned, the quality of the *work* performed in the *construction* is really the important factor, as the best materials can not give good results unless properly handled.

When the conduit is to be built by contract, detailed specifications should be prepared and the work should be thoroughly inspected while in progress.

The fact should be constantly kept in mind that the work is to be immediately and permanently covered from view, and any defect in material or construction will remain a defect and become a part of the system; while a conduit intelligently designed and carefully constructed in all details gives a sense of security and pleasure in operating and becomes an asset of increasing value.

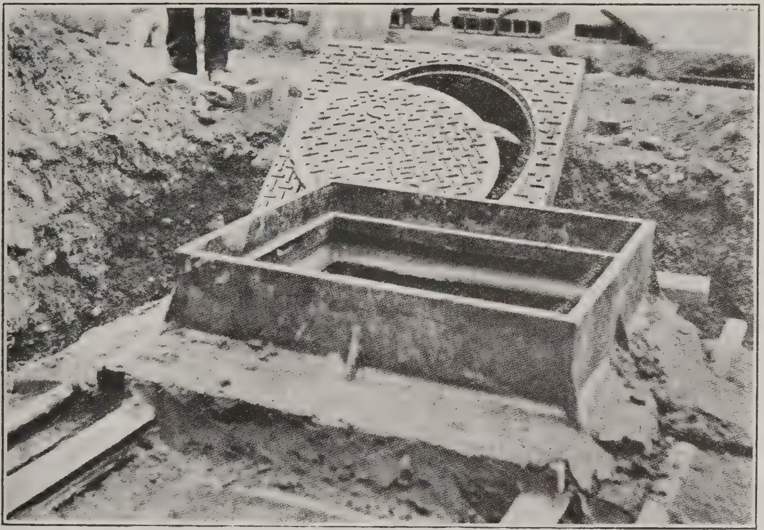


Fig. 8. Combination Manhole Frame and Cover

The lecture was illustrated by lantern slides, some seventy-five or eighty views being shown to illustrate the various points referred to.

While these views were upon the screen many questions were asked as to the speaker's opinion upon definite subjects.

Some of the questions asked from the audience and Mr. Harrington's answers were, in substance, as follows:

Question. What is the probable life of the wrapping of burlap,

saturated with hot asphalt, used for covering the joints of vitrified clay ducts?

Answer. The life of this wrapping would probably be considerably different in different soils and under different conditions. Judging from observation, I should say that the probable limit would be ten years.

Q. Have you had occasion to notice bad results of the effect of lime salts, in water which has percolated through cement concrete, on the lead sheaths of cables laid in cement ducts?

A. I have had the question of the effect upon the lead sheaths of cable by contact with wet cement concrete called to my attention and have noticed some slight effects upon the lead, but have never noticed serious trouble to the lead sheaths on this account, although I have examined cables that have been in cement ducts for ten years or more.

Q. What is the comparative cost of the conduit of vitrified clay ducts against fiber ducts?

A. I have the impression that the present price of vitrified clay ducts and fiber ducts are about equal, though I have not had a recent quotation on tile duct. The cost of fiber duct has been the past year somewhat higher than tile, but taking into consideration the expense of freight, teaming, handling and breakage, the final cost of the two conduits has been practically the same.

Q. Have you ever had experience with cables being heated by the friction of drawing them in and softening the fiber ducts so that the cables stick to the ducts?

A. Our experience with fiber ducts has only covered a period of eight years, but during that time I have never known of a condition of this kind; on the contrary, reports which have come to me have shown that the cables pull very easily through the fiber ducts.

There have been objections made to large conduits because of the heating, electrically, of the cables in the ducts and the fact that the cables in the center ducts in the large conduit are not cooled by contact with the surrounding ground as they would be in the small conduit. It has been reported that this has decreased the efficiency of cables in the center of the large conduit, in some cases perhaps 30 per cent.

Q. What is the advantage of building large conduits?

A. Principally the matter of economy in construction. While a conduit of eight ducts would cost $2.60 per conduit foot, two conduits of four ducts each would cost $3.80 per foot; while a conduit of forty ducts would cost $6.50, two conduits of twenty ducts each would cost $8.00, and having a conduit of thirty ducts, six ducts could be added to it at a cost of perhaps 90 cents per foot for the

six ducts, while to construct a separate conduit of six ducts would cost about $2.00 per foot.

Q. Is it advisable to use treated timber for covering plank at the extra cost?

A. I think it is certainly desirable to have a covering plank treated for preservation. A covering plank is a great factor of insurance from mechanical injury; I have examined kyanized and creosoted covering plank which I had laid twenty years before and found that while the untreated boards immediately beneath the

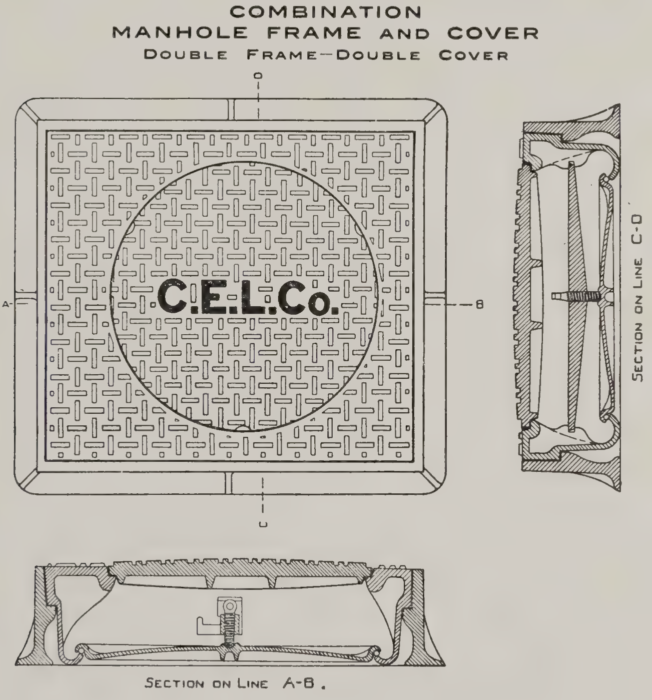


Fig. 9. This set of manhole castings combines the round outer cover 26 inches in diameter for ordinary use, the seat for the elongated inner cover for use when required, and the rectangular cover leaving a clear opening 32 by 36 inches for installing transformers, junction boxes, etc.; this rectangular cover also serves as a frame to support the round top cover and the oval inner cover. The 26-inch cover is of a convenient size for use when inspecting or handling cables; the oval shape of the inner cover is a distinct advantage when entering and leaving the manhole or pulling cables, and the deep seated large rectangular cover is fitted so as to leave a joint which can easily be caulked and, with the inner cover forced on to a gasket, gives a water-tight manhole top without probability of excessive damage in case of explosion.

covering plank were almost entirely gone, the covering plank was in very perfect condition.

Q. What is the proper thickness of concrete for the bed and side walls of the conduit?

A. Different engineers have used various thicknesses of concrete, some have used 6 inches at the top and bottom of the conduit with 3 inch side walls; others have used 2 inches all round, but I think that in the larger number of cases that have come to my notice the walls have been made 3 inches thick on the top, bottom, and sides. When using ducts which make a straight smooth side against which to place the concrete, I think it is desirable that the concrete wall should be at least 3 inches thick. When round ducts are used, with spaces between which gives the concrete a better bonding, it would be safe under some conditions to reduce the side walls to 2 inches or even 1½ inches as has been done in some cases.

Q. How do you consider the life of fiber duct would compare with tile?

A. The fiber duct has not been used for conduits underground for a long enough period to absolutely determine how it will act after many years.

We know that vitrified clay under favorable conditions will last for a very long time.

While the manufacturers of fiber duct do not claim absolute proof of long life, many discriminating engineers are sufficiently satisfied on this point, after considering the character of the materials used in its manufacture, to recommend it for permanent work.

Q. Is it necessary to use sideboards for conduits in all cases or can they be dispensed with when the earth will stand alone?

A. In some soil, such as a loamy sand, where the trench can be accurately cut to the desired size for the conduit, there seems to be no necessity for using sideboards; but where the soil is coarse, even though it would stand with perpendicular sides without bracing, it is generally economical to use sideboards to save the use of unnecessary concrete and also because a smooth finish on the outside of the concrete is an additional safeguard against damage to the conduit.

Q. Is it economical to remove sideboards after the conduit has been placed?

A. When the sideboards are made of 1-inch boards, with cleats, I do not think it is economy to remove them, because the cost of filling in the hollow space left and the damage generally done to the conduit in the removing would overbalance the cost of the sideboards.

When sheet steel is used to confine the concrete for the conduit it is practical to remove it, but considering the troubles with ob-

stacles, etc., I doubt if there would be economy in using even the sheet steel as compared with the cost of permanent sideboards.

Q. How far is it best to put conduits below the surface of the ground?

A. A convenient and satisfactory arrangement is to provide in the start for a cover of about 2½ feet over the top of the conduit; this will generally be an economical depth for construction in the matter of avoiding other pipes and also place the conduit at a satisfactory depth in the manhole.

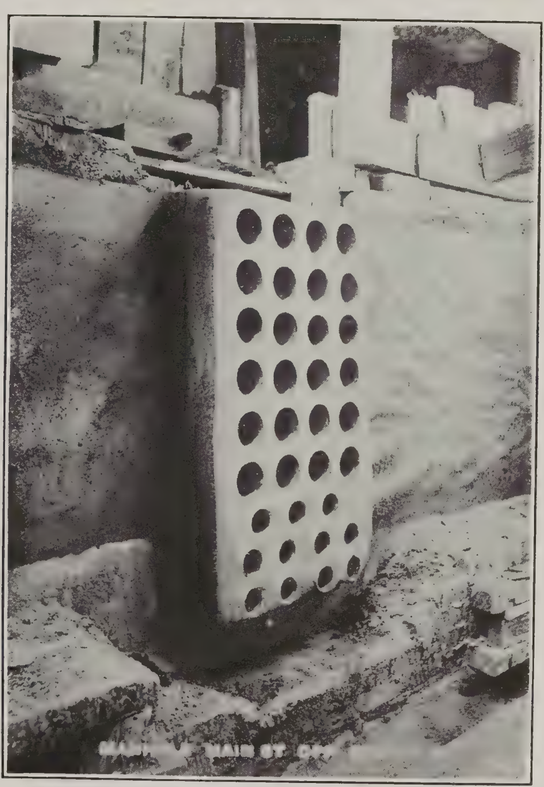


Fig. 10. Waterproofing on Wall of Manhole and Seal around Fiber Ducts

A shallower construction, up to 18 to 20 inches, is not seriously objectionable between manholes and at points where manholes are not likely to be required in the future.

Conduits may, of course, be placed at any greater depth, providing the manholes are also made sufficiently deep to receive them.

Q. Is there advantage other than convenience in having water-tight ducts?

A. There is quite an advantage, in insurance for the lead sheath of cables from injurious chemical ingredients of the soil and from electrolysis, in having a water-tight barrier somewhere between the cable and the outside soil and, incidentally, the barrier will generally keep out gas as well.

Q. Do you think a water-tight conduit can be made with tile duct?

A. I do not think the individual vitrified clay ducts can be made water-tight by any process within reason; the socket joint is an advantage in keeping the alignment true and making it possible to use more pressure in placing the concrete, thereby making it more nearly water-tight; in my practice I have found that in order to make a conduit of clay ducts water-tight it is necessary to place a waterproof coating around the group of ducts or around the concrete of the conduit.

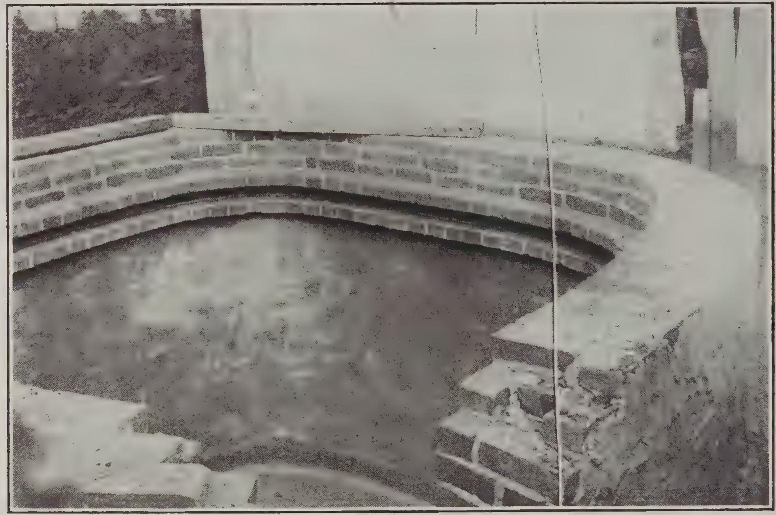


Fig. 11. Transformer Manhole Waterproofed

Q. Would you favor the use of the flexible steel wrapper for joints of clay ducts?

A. I think it might be useful to strengthen a cement joint on a clay duct where no concrete envelope is to be used. I do not think it would take the place of the cloth wrapping to keep the grout from running into the ducts.

A number of lantern slides were shown and explained in detail by Mr. Harrington, describing the construction and installing of submarine conduits made of untreated wood which have been in successful use for ten years.

AN EXPERIMENT IN WOOD PRESERVATION

BY

MR. M. MEIGS
United States Civil Engineer

In 1889, the writer was engaged under Major, now General A. Mackenzie, retired, in designing and building of the United States dry dock at Keokuk, Ia., which is attached to the Des Moines Rapids Canal. This dock is 400 feet long at bottom and 100 feet wide, and is filled by gravity from the canal and discharged into the river, which, at all ordinary stages, is below the level of the bottom of the dry dock.

The grillage on which the boats are supported when the dock has been emptied consists of timbers, in local parlance "logs," crossways of the dock at intervals of 16 feet. These logs rest upon sills consisting of 12 by 12 inch pine timbers, bedded in the pavement of the dock bottom, and projecting above the surface of the dock 3 inches. The photograph, Fig. 1, shows these features very clearly, and the dock is described in detail in the Report of the Chief of Engineers, 1886, Vol. II, pg. 1477.

The material below the level of the dock was originally soil about 4 feet thick, below which was ledge rock. The soil was all removed and replaced by gravel, dredged from a bar in the river near by; the pavement consisting of coursed rubble, hammer dressed in blocks about 10 inches long and 6 inches wide, and 8 to 10 inches deep, closely laid on edge, but with no cement between the joints.

The sills, eight in number, extend the length of the dock 400 feet, or 4,800 lineal feet of sill in all. (The writer is thus particular about the surroundings of the sills, as on this must be based any judgment as to the experiment itself.) They rest upon concrete walls the same length as the sills. In putting the sills in place there was first dug a trench in the gravel about 18 inches deep and 14 to 16 inches wide, and the sills were suspended temporarily over this trench, which was afterwards filled up with cement concrete until the cement reached the bottom of the sills. The pave-

ment was then laid close to the timbers, the top of the pavement being kept 3 inches below the top of the sill.

Holding-down bolts were necessary at intervals to overcome the upward pull of the sills and logs attached thereto, and these bolts were about 30 inches long of ⅝-inch iron. The bolts had a nut and washer at one end and a right-angled bend at the bottom, forming a hook to prevent them from pulling out of the concrete. The bolts being inserted in the timber before it was put in position, as the work of concreting the foundation proceeded, these bolts were firmly embedded in the concrete and performed their office very well for a long time. Of late years, however, some of these sills have shown in places a tendency to lift, and to hold them down, all the spare scrap iron about the place was piled at intervals on them. It was found on inspection that some of the hooks or lugs had wasted and had finally broken off, allowing the bolt to draw up through the concrete and the sill to lift; therefore, it became necessary this season to take up some of the timbers and reset them, and it gave an excellent opportunity to inspect the wood. Each one needing it, in pieces about 20 feet long, was raised; the trench it occupied in the pavement was cleaned out; holes were bored through the timbers, 6 feet apart, large enough to permit of inserting an ordinary quarry drill. New holes were then drilled in the concrete, new ¾-inch bolts inserted with a large washer and nut at the top end, and the bolts were grouted with Portland cement, which renewed the anchorage of the grillage to the concrete foundation very successfully.

Now, when those sills were first put in, in 1889, the writer tried an experiment in wood preservation. Obviously, those long sills would be difficult and expensive to replace, and any increase in the life of the timber would be a considerable gain. The method of preservation adopted was to bore the timber nearly through, at intervals of 4 feet, with a 1½ inch auger, fill the hole nearly full of sulphate of copper, and then plug the hole with a plug about 1 or 1½ inches long. This simple and inexpensive protection seems to have had unusually good results. In every timber bored for inserting the new anchor bolts, and about twenty-five of the 20-foot timbers were thus bored, the wood ½ inch below the surface seems now, after twenty-one years of partial burying in the ground, to be in as good condition as when first put down.

The preservation has been so good that test holes were bored at random in many other timbers which did not require repair, to see

if all were alike, and in every case the auger brought out bright fresh chips like a new stick. A few of the timbers in the 4,800 linear feet of the whole lot were very sappy on the top side, and this sap wood in some cases has fallen away to the depth of the heart wood, but the whole of the heart wood of the timber is still sound and good and perfectly well fulfills its office.

Unfortunately, the writer did not look forward far enough to leave one of the sills untreated with the copper sulphate as a control experiment, and the question now arises "What would have been the present condition of these timbers had no effort been made to increase their life by using sulphate of copper?" It looks to the writer as if the ordinary white pine and Norway timbers, such as those used, would by now have been completely rotted out. The timber is exposed to sun and rain; is alternately wet and dry, and while sometimes a dockage may not be made for several months, at other times the dock is filled and emptied two or three times in a week. The timbers are really exposed somewhat, the same as a railroad tie is, though it projects above the surface of the ground

Fig. 1. U. S. S. *Arthur Hider* in dry dock at Keokuk, Iowa; showing construction of grillage and location of sills

more than the latter does on a well kept up railroad, and it seems to the writer the exposure the timbers have had is more severe than any tie ever gets because damper, and more exposed to the weather. Moreover, these sills are of pine and the usual railroad tie is of oak.

Altogether, the preservation of the timber appears remarkable, and those engineers and others who have inspected it have been surprised at its condition. One timber that was removed during the repairs was not put back, but a new one was substituted in its place, and the old timber kept for a specimen. This timber, split in two by wedges, is the subject of Fig. 2. The grain of the wood is perfect, the color unimpaired by its twenty-one (nearly twenty-two) years of partial interment. The borings taken from the new holes for the anchor bolts were saved and mixed together, and a sample of these borings has been sent to Major Connor, Corps of Engineers, United States Army (the editor of this journal), for examination.

Fig. 2. Sill at United States dry dock, Keokuk, Iowa, preserved by sulphate of copper. Laid in 1889, taken up in 1909, and shows no deterioration

It will be noticed that many of the chips are green, showing a copper stain. These chips came from holes that were nearest the sulphate of copper pockets. Traces of the stain could in many

cases be seen at least 2 feet from the place where the copper was inserted, showing that the whole wood was permeated.

The cross logs were also treated with the copper sulphate. These logs are exposed completely to the air and are not in nearly so good condition as the sills. The application of the sulphate was, however, different, and seems to have had much to do with the preservative action of the copper. In the case of logs, holes were bored in the *center* of the *ends*, filled, and then plugged as on the sills. Now, these end holes do not cut across the annual layers of wood, as a hole bored cross-wise would do. A hole bored radially communicates with each layer of wood from the center out, while one parallel to the growth of the tree seems much less favorably situated for capillary distribution of the chemical in a damp state. This may account for the smaller preservation of these cross timbers.

These notes are submitted by the writer to his brother engineers for what they are worth and for discussion. Possibly the timbers would have lasted without treatment. So far, as many as have seen the timber have been of the opinion that the sulphate of copper is the cause of this timber preservation, and that without it they would have rotted away. What do you think?

TERMINAL FACILITIES IN THEIR RELATION TO WATERWAY IMPROVEMENT

BY

Maj. GEORGE A. ZINN
Corps of Engineers

A recent act of Congress (March 3, 1909) requires that reports upon preliminary examinations and surveys of proposed waterway improvements shall include such data as it may be practicable to secure regarding the establishment of terminals and transfer facilities, considering only their bearing upon the improvement of navigation and the possibility and desirability of their being coordinated in a logical and proper manner with improvements for navigation.

The various parts of a water transportation line may be grouped in the following manner: *first,* the cargo carrier, including its motive power; *second,* the main waterway or channel along which the cargo carrier is moved between terminals; *third,* terminal facilities—the means and appliances used to transfer the cargo from the carrier to the shore or to another carrier for further transportation, and *vice versa.* The third group forms the topic of this paper.

The words ''terminal facilities'' have been used freely by recent writers and speakers, and generally include transfer as well as terminal, and will in this paper be used to mean not only those at the terminus of a water line, but also those at intermediate points of the line where trans-shipment or reloading and discharging take place.

The interest which Engineer officers have in this subject will be covered, it is believed, by finding answers to the following questions:

1. What are the essential elements of a water terminal?

2. What influence have terminal facilities upon cost of water transportation?

3. What elements of terminal facilities for water transportation should be provided by the United States?

TERMINAL FACILITIES DEFINED

By classifying the waterways which form essential parts of water transportation lines, as (1) channels, (2) harbors of refuge, and (3) anchorage basins, we exclude such waterways as are properly included in the term "terminal facilities." The above classification may be objected to on the ground that anchorage basins are in reality essential features of all terminals. This may be true, but since all water transportation lines do not require separate anchorage basins, and some none at all, and because an anchorage basin may be readily treated as a separate subject, such basins may be omitted from the present discussion. In the usual case an anchorage basin will be used by all vessels entering or leaving a harbor, hence it really belongs to the common waterway, and is an accommodation to prevent congestion in the latter.

What, then, are the terminal facilities required for a water transportation line? This question receives a preliminary and simple answer: *Terminal facilities* are those appliances, apparatus, machines, etc., whether fixed, movable, or floating, necessary for the movement of goods and passengers from a floating vessel to the shore, or to another vessel; the place or places, on land and water, where trans-shipment is effected, and the buildings, machinery, etc., which may be necessary for the storage of the cargo. The derricks and machinery now so commonly found on tramp steamers and bulk-freight carriers are not included in this definition, nor does it include the appliances and machinery used in the removal of the cargo from the water terminal to distant land points, the latter forming part of a land transportation system.

In more detail, the elements of water terminal facilities are *first,* floating devices, such as tow boats, lighters, floating derricks, floating elevators, used in removing the cargo from a vessel and in transporting it to the shore; *second,* the wharves, piers, quays, or other solid structures on shore or floating structures tied to the shore or bank, against which a vessel lies while the cargo is being removed or loaded; third, the cranes, shears, railroad tracks, and other machinery on shore used in removing the cargo from the vessel and in storing it, whether in the open or in a building; *fourth,* the elevators, warehouses, and other buildings used for storage; *fifth,* the open spaces on land required in handling cargo;

sixth, the waterway used by a vessel while in process of discharging, and the waterways through which the vessel passes, after leaving the channel used by it in common with other vessels passing to and from other points, to reach the place where transshipment or discharge is to be effected. These latter waterways have various designations such as channels of approach, harbors, slips, basins (open and closed), docks etc. Locks are sometimes constructed in connection with these features, but their cost is more properly assimilated with that of the quays built in connection with them than with that of the channel of approach. Marine railways, dry docks, repair shops, are necessary to carry on transportation by water, but they do not form essential elements of a terminal.

To the reader familiar with methods in various parts of the world, no further definition of ''terminal facilities'' is necessary. They include the bank of the Ohio, with its revetted slope and wharf boat, or the unrevetted bank against which the boat's bow is held by the moving stern wheel, while the cargo is moved over the swinging gang plank; they include the elaborate quays and docks of European ports; they include the little tugboat which moves the vessel, and the floating shears or elevators for removing the cargo; they include the rowboat with which passengers are landed from the ship, and the shed or elevator in which goods and grain are stored; the two-wheeled hand truck, or the stevedore's muscles, and the powerful steam crane used in unloading coal. They include the place in the channel where the vessel may be obliged to lie to discharge cargo, and the waterway used by it in moving into a slip or dock.

THE RELATION OF TERMINAL FACILITIES TO COST OF TRANSPORTATION*

It may be laid down as a broad rule that the outlay for terminal facilities is commensurate with the annual tonnage of receipts and shipments and more or less independent of their unit value, size, or

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*Much information on this subject is given in several papers presented to the tenth meeting of the Permanent International Association of Navigation Congresses under the title ''On the Advantages and Organization of Mixed Transports—that is, by railways and waterways.'' The authors show that the development of inland navigation in Europe has always been followed by a general economic development and that the installation of common terminal facilities has always resulted in increased rail and water shipments. One of the authors proposes that railway companies shall be forced to provide a junction with adjacent water terminals.

characteristics, as well as of the form or size of the vessel on which they have been transported. Physical conditions may, however, prove a factor of more or less importance. A very small daily tonnage or an infrequent large cargo will warrant facilities of a primitive nature only, while a large daily tonnage of package freight, or a large daily tonnage of bulk freight of a single material (coal, ore, etc.) results in the installation of elaborate and costly terminal facilities. The cost of the operation per unit will be much larger in the first instance than in the second. Where the cost of providing terminal facilities, by reason of the lack of a natural or easily improved harbor, is relatively excessive, a very large increase in tonnage would be necessary to induce the establishment of adequate facilities. The installation of terminal facilities generally follows a demand for them, and the outlay is in proportion to the tonnage; yet, on the other hand, instances are known where the installation of terminal facilities of a greater magnitude than present commerce had seemingly warranted has resulted in attracting commerce. In fact, where such installation has not resulted in an increase of commerce it has been due to peculiar or changing industrial and commercial conditions, or perhaps because certain difficulties in the channel of approach to the terminus have not been removed.

Where vessels can be docked, a reduction in cost of discharging can be effected only by installing more powerful or more swiftly moving machinery for removing the cargo. Where vessels can not be docked, either docks and channels of approach must be constructed for them or more capacious and powerful lighters and floating cranes must be provided, and these again require adequate channels of approach and adequate machinery on the quays.

Freight rates on a combined land and water route, in the general case, depend upon terminal facilities (*i. e.*, cost of trans-shipment) as well as upon the cost of transportation by the separate parts of the route.

Where shipments can be made between points of origin and destination by several independent combined water and rail routes, the choice of the point of trans-shipment will, in the general case (*i. e.*, when railroad rates are not fixed by combinations among the railroads), depend upon the terminal facilities, as in the case of grain for foreign markets and coal for domestic coast ports.

Where a railway line is parallel to a navigable waterway, its freight rates between common points are, in the general case, made

the same as those on the waterway, and the consignee may be influenced in his choice of route by the location of the terminal facilities, or by dispatch. The establishment of terminal facilities by the coal-carrying railroads at points in the Chesapeake Bay has encouraged the construction of large vessels specially fitted for carrying coal, with a resulting reduction in freight rates; on the Great Lakes a similar result has been brought about in ore carriers.

Extensive and costly water terminal facilities are, as a rule, not demanded for local business; they are found only where facilities are required for trans-shipment of large quantities of freight brought by rail from inland points for carriage by water to distant points, or for freight moving in the opposite direction. That is to say, extensive water terminals exist where extensive railway terminals exist, and they must be planned to meet the demands of each other. Where a seaport is the center of an extensive inland water system, it will also require extensive terminal facilities for trans-shipment of goods from ocean vessels to other vessels especially adapted to inland navigation. The port of Shanghai is an example of this class.

If merchandise may be shipped from one point to another either by an all rail line or by a combined rail and water line, the rail rates are generally so fixed as to discourage shipment by the combined line, with the result that the water transportation lines make no serious effort to develop their terminal facilities. If, however, water competition becomes so powerful that it can not be overcome, the railway lines have sometimes purchased and put on vessels of their own, and the water terminals are then developed by the railway line. Examples of this effect are found in shipments of coal on the Atlantic Coast, and of ore on the Great Lakes.

THE RELATION OF THE UNITED STATES, STATE, AND MUNICIPAL GOVERNMENTS TO TERMINAL FACILITIES FOR WATER TRANSPORTATION

The parts of a water transportation line are susceptible, as previously stated, of being grouped under the terms, cargo carrier, channel, and terminal. The construction, maintenance, and operation of each of these groups, or of all of them, may be conducted by private individuals, by local authorities, or by the General Government.

The Preliminary Report of the National Waterways Commission (see Doc. No. 301, 61st Congress, 2d session) has just been made

public, and in it will be found much information pertaining to the subject of this paper. Its contents are familiar to the reader, or are available to him. The methods employed for financing waterways are shown in the report for Belgium, France, Germany, Holland, Austria-Hungary and Great Britain. It appears that state and local expenditures for waterway improvement are divided in varying proportions. In some cases the state bears the entire expense, in others 50 per cent of it, and in others the local authorities provide the terminal facilities. It does not appear definitely that governmental authorities operate the terminal facilities or the transportation lines, but in one of the reports presented to the Permanent International Association of Navigation Congresses, in 1908, the statement is made that the question of forming a governmental monopoly of towing on the canals is under consideration in Germany, with the idea of establishing a regular and quick movement.

The decided tendency in Europe is shown in the National Waterway Commissioner's report to be toward a degree of participation by communities and localities especially benefited by the development of the waterways. The Commission expresses its opinion that terminal facilities, which are an integral part of any well-devised plan for waterway improvement, should be provided by the communities immediately benefited, that uniform rules should be observed for a proper division of the cost of improving rivers and harbors between the federal government and minor political divisions, and that improvements should not be undertaken unless sufficient assurance is given that "proper wharves, terminals, and other necessary adjuncts to navigation shall be furnished by municipal or private enterprise, and that the charges for their use shall be reasonable." The Commission also says that "'minor channels leading to wharves in harbors, as well as upon rivers, should be provided by communities or individuals," and that "in deciding whether a harbor improvement is to be adopted or not, it is wise to omit those cases where there is not assurance that local or private enterprise will furnish all needed terminal facilities." By implication, the Commission recommends that the improvement of all other waterways should be undertaken by the United States Government. These recommendations conform to present practice in the Engineer Bureau, in that minor channels, wharves, terminals, and other adjuncts to navigation are omitted from projects for improvements, and with the exception that guarantees to fur-

nish these have not heretofore been demanded from local authorities or individuals. The recommendations of the Commission may be accepted as principles, and applying them to the various parts of a water transportation line, they mean that the cargo carrier, including its motive power, and the terminal facilities, should be constructed, maintained, and operated by local authority or individuals, and that the channels, harbors of refuge, and anchorage basins should be constructed and maintained by the United States.

Several decisions by the Supreme Court of the United States establish the limits of jurisdiction of the States and of the United States over navigable waters within their boundaries. In Miller *v.* Mayor of New York and Others, the Court states: "The power vested in Congress to regulate commerce with foreign nations and among the several States includes the control of the navigable waters of the United States so far as may be necessary to insure their free navigation; and by 'navigable waters of the United States' are meant such as are navigable in fact, and which by themselves or their connection with other waters form a continuous channel for commerce with foreign countries or among the States." In Escanaba Company *v.* Chicago, this power is extended to "protect, preserve, and improve their free navigation." In County of Mobile *v.* Kimball, this power is considered to be exclusive. In the latter case it is stated that State legislation is not forbidden touching matters either local in their nature or operation, or intended to be mere aids to commerce, such as the improvement of harbors, bays, and navigable rivers within a State, if their free navigation under the laws of the United States be not thereby impaired. Congress, by its non-action in such matters, virtually declares that, for the time being and until it deems fit to act, they may be controlled by State authority. In Transportation Company *v.* Parkersburg, it is declared that "Although wharves are related to commerce and navigation as aids and conveniences, yet being local in their nature, and requiring special regulations at particular places, the jurisdiction and control thereof, in the absence of Congressional legislation on the subject, properly belong to the States in which they are situated." In many other cases, the same doctrine is established, that the United States has exclusive jurisdiction over navigable waters within its boundaries. A navigable water is defined to be one which is navigable in fact. Again, "if a river is not of itself a highway for commerce with other States or foreign countries, or does not form such highway by its connection with other

waters, and is only navigable between different places within the State, then it is not a navigable water of the United States, but only a navigable water of the State.''—(The Montello.)—''In order that the passageways of commerce and navigation might be subject to public authority and control, the title to the land under water and to the shore below ordinary high water mark, in navigable rivers and arms of the sea, was, by the common law, vested in the sovereign for the public use and benefit. * * * In Iowa, the true rule has been adopted; and it is held that the bed of the Mississippi River and its banks to high water mark belong to the State.'' (Barney *v.* Keokuk); and in Gibson *v.* United States, ''although the title to the shore and submerged soil is in the various States and individual owners under them, it is always subject to the servitude in respect to navigation created in favor of the Federal Government by the Constitution.''

These decisions not only affirm jurisdiction, but also exhibit the extent of jurisdiction by affirming the power to improve to ordinary high water mark. No legal restriction has been placed upon this power of improvement, except that ''no money appropriation for the improvement of rivers and harbors * * * shall be expended for dredging inside of harbor lines duly established.'' (River and Harbor Act, approved July 13, 1892.) The restrictions imposed upon individuals, States, etc., are that it is unlawful to construct docks and wharves in any navigable water of the United States or bridge over such waters, or to excavate or fill, or modify the condition of such waters, or to deposit refuse, etc., in them, or permit or cause to be sunk vessels, or other craft, without the authority of the War Department.

The power to improve navigable waters, the extent of this power, the restrictions imposed with respect to improvement and injury to navigability and the recommendations of the National Waterways Commission are comprehensible, but the Engineer officer to whom is assigned the duty of preparing a project for improving a certain waterway will generally find some difficulty in applying them. It is evident that the United States should construct and maintain channels, harbors of refuge, and anchorage basins in its navigable waterways, including all the permanent and temporary structures necessary thereto; that it should not construct, maintain, or operate the cargo carrier with its motive power; and that it should not construct, maintain, or operate the fixed or floating structures, machines, appliances, etc., pertaining to terminal facili-

ties. There may, however, be some difference of opinion with respect to waterways lying between the shore or fixed structures and the channel. Where should the dividing line be placed between them? No rules have yet been adopted or even proposed for establishing this dividing line. It is evident, however, that no waterway should be improved by the United States or a State which can only be used or is to be used exclusively for the benefit of private individuals or corporations. Nor should the United States or a State improve a waterway (berths, slips, docks) which can be used only by vessels while discharging cargo alongside a wharf owned by a single individual or corporation. Further than this it does not seem possible to go.

The duty of a State to improve the waterways over which it may have exclusive jurisdiction, and its power to improve the navigable waterways of the United States lying within its boundaries is manifest, but can it be said that it is also its duty to share the expense of the latter with the United States Government? This question may be political in its nature, and therefore may not concern the Engineer officer. He is, however, required to express his opinion whether a certain waterway is worthy of improvement by the United States, and whether this requirement permits him or not to report upon the matter of the share which a State should bear on the total cost of improvement, it is probable that the Engineer Bureau or a district officer may be called upon to answer this question at some future time. It is pertinent therefore to discuss the question so far as it bears upon advisability of improvement. Is there any rule not absolutely arbitrary or principle which could be laid down to form a basis to determine the dividing line between that portion of the waterway which should be improved by the United States and that by the State, or to determine the share of each in the cost of a waterway improvement? Some one or more things or facts must be used as the groundwork for a rule. If the United States improved only those waterways not included within the boundaries of a single State, some of our most important rivers and harbors would be excluded. Expressing this in another way the rule would be: States shall improve all waterways lying entirely within their own boundaries. The various States might thus have burdens imposed upon them which have no relationship with the benefit they receive from them, and would probably not undertake to improve their waterways in any definite or adequate manner Other States would suffer in development. If the cost of an im-

provement were to be apportioned between the United States and the State within whose boundaries the waterway was enclosed, according to the relative benefits which that State and all the other States combined received from the improvement, other rules would be necessary to determine how to discover the relative benefits. There is one class of harbors which might perhaps be placed under this rule, *i. e.*, those which are located on small islands or which have no communication with the interior except by wagon road, and, consequently, whose commerce must be local. Tidal rivers with the same characteristics as the harbors just mentioned may also be included in the same category. In the case of harbors like Boston, Philadelphia, Baltimore, the benefit received by the State in which they are located and by the various other States of the Union would be very difficult to determine. Is it not far easier to imagine that all artificial State boundaries have been obliterated, to define navigable waterways of the United States as those which are actually navigable and which connect by other navigable waterways with the various oceans of the world, and then to decide that the United States shall improve all of its navigable waterways, leaving to the States, local authorities, or individuals the improvement of waterways which are not included in the definition?

RELATION OF TERMINAL FACILITIES TO ADVISABILITY OF WATERWAY IMPROVEMENT

The advisability of improving a waterway can only be determined by comparing cost and benefit; that is, by determining the relationship between the cost of construction and maintenance of the improved waterway, and of the benefit which the present and prospective industries and commerce of the country will derive from the improved waterway, expressed, if possible, in terms of the same unit of measure. Do terminal facilities affect advisability, and in what manner? They are essential features of both rail and water transportation lines and particularly of joint rail and water lines. It has been shown elsewhere that industrial and commercial conditions, as represented by shipments and receipts of merchandise at joint terminals, are always stimulated by the installation or improvement of such joint terminals. Raw materials and manufactured products generally require a long haul from place of origin to place of consumption, over routes on which combined rail and water lines may be advantageously used. A joint terminal is generally

located at a place where it is advantageous to collect and temporarily store small lots of merchandise for transportation in bulk to distant points, or for distribution by other transportation lines or means to consumers.

At localities where vessel cargoes are consumed in the immediate vicinity of the water terminal, their distribution will be made by wagon, or light railway; or where the products of the immediate vicinity can be shipped only by water, their collection will be accomplished by the same means. A condition is assumed in which traffic is local and the movement of merchandise is small in amount, and which actually exists at many small harbors and rivers in the United States. A very small expenditure on the waterway may render navigation much less difficult or dangerous—for instance, by the removal of snags or boulders, or a slight amount of dredging, or it may eliminate the delay occasioned by insufficient depth. The improvement thus brought about may be amply justified, whether we consider the benefit to present commerce alone, or to local industries and commerce by stimulation of growth, and without taking into consideration existing terminal facilities. It has been suggested that it would be advisable to impose a condition "to the effect that wharfage facilities shall be made available to the public generally and that the charges for the same shall be submitted to the Secretary of War or other official for his approval."

At localities where the shipper has a choice between an all rail or an all water route, the terminal facilities will enter into his calculations. The relative location of the two terminals to his place of business, and the relative cost of handling merchandise, may be such that the total cost of transportation will be less by the route which has the higher freight rate. In order to benefit the shipper by improving the waterway, the water rate, usually already lower than the rail rate, must be lowered sufficiently to overcome the disadvantage of terminal location or greater cost of handling, or both. In other words, the waterway improvement alone is expected to produce an effect which, in the majority of cases, could be brought about by improving the terminal facilities. Until the latter have been developed or improved to meet the new conditions which may be brought about by the use of large vessels, or vessels more suitable for rapid discharging than those now in use, the full measure of benefit possible with the improved waterway can not be secured. The study of advisability in such cases, should, therefore, include a careful consideration of the terminal situation, and a

careful comparison of the respective effects of improving the terminal facilities and of improving the waterway.

At localities where the shipment of merchandise may be made by an all rail line, or part way by rail and part way by water, the conditions affecting trans-shipment from the rail to the water line, as well as conditions at the water terminal, seriously influence the total cost of transportation from origin to destination. If the rail and water lines have no common terminal, the cost of trans-shipment is relatively large when compared with cost of transportation by rail or by water, and even with common terminals the cost of trans-shipment is never a negligible item in the total cost. Nor can drayage and stevedoring be omitted. If the cost of these factors be expressed in rates per ton, the effect upon the total cost of transportation produced by an improvement in transfer and terminal facilities or in the waterway, on any given combined line, can be ascertained, and this in its turn combined with total tonnage of shipment will give the total benefit of improvement for comparison with total cost of improvement. In the preceding case, it was seen that terminal facilities, as well as waterway improvement, must be investigated to arrive at a safe conclusion upon advisability of improving the latter. In the case now under discussion, the condition of the transfer facilities must be investigated as well. It is evident that an improvement in any one of the factors of cost will reduce the total cost of transportation, but an equal reduction in total cost may involve the expenditure of very different sums of money. Should it be considered the duty of the United States to improve a combined waterway, if the terminal and transfer facilities provided by private individuals are inadequate, inefficient and expensive as to rates? Could the United States be expected to so improve the waterway that the cost of water transportation will be sufficiently diminished to make the combined rate less than the all rail rate, notwithstanding relatively high transfer charges? The conditions may be such that this could not be done, but advisability of improvement can not be definitely determined without investigation into every factor.

Under present conditions in the United States, railroad lines are permitted to meet water competition by lowering their rates between competitive points. By refusal to install common terminals, and to prorate with water lines at common terminals, they have prevented shippers from taking advantage of the cheaper rates of water transportation at certain common points. At other points,

the railroads have established their own water lines to meet the competition of independent water lines, or to provide for water delivery of certain classes of merchandise in certain markets where the cost of railroad transportation appears excessive for one reason or other. It is therefore difficult to foretell at the present time the changes which waterway improvement would effect in rail rates. That rail rates may be increased or diminished at will does not, however, alter the fact that terminal and transfer facilities should be investigated in connection with the question of waterway improvement.

Railroads and private parties may or may not be willing to establish adequate combined terminals, and there appears to be no law under which they can be compelled to do so, but the United States might well "omit those cases where there is not assurance that local or private enterprise will furnish all needed terminal facilities."

GENERAL DESCRIPTION OF THE DEPRESSION POSITION PLOTTER*

BY

Mr. D. E. HUGHES
Assistant Engineer

The instrument to be described is intended to be located at or near the coast on a hill or other elevated position which will afford a vertical base of sufficient height above the water, to be of practical use in determining distances on the water. The purpose is to determine, and automatically plot upon a map, the position of observed points on the water's surface and the continuous courses of moving floating objects. Its application would be principally in connection with seacoast defenses in times of war, in indicating the positions and courses of the enemy's vessels. The particular uses would be to the battery commander, in giving in the shortest time and with the least number of men and the smallest chance for error, the course of a vessel to be fired at, from which is predicted the advanced position to be reached by the heavy guns; and to the fire commander or battle commander, in showing without delay which zone and sector, or square upon his map is occupied by the enemy, that he may know what batteries can be brought to bear; and to the mine commander in indicating with least confusion up to the last second of time which of a group of mines the enemy is approaching most closely. A minor use of the instrument would be for the observation of fire, in which the observer would track the target until the splash appeared, thence pass quickly to the splash, thence back to the target without stopping to note azimuths and ranges, which could be determined as well later at leisure by simply bringing the pencil back to the points.

It would be often advantageous to have a continuous reliable record for future reference, of all that had been observed, and for such use the plats could be dated and filed away. Of course, the pencil would be raised or removed when plotting is not desired.

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* Designed September, 1903, by D. E. Hughes.

It would not be necessary to use real maps, for plain paper would answer the purpose, on which, after securing it to the table, a few known points would be plotted by the instrument either by direct observation on the points themselves or by setting the instrument at their known azimuths and ranges.

Hydrographic surveying from vertical bases has long been practiced; the height of instrument and angle of depression being sufficient data for determining distance either by calculation or by reference to a constructed graphical scale. Then surveying of the same waters from a selected high permanent station becomes such as to warrant the construction of an instrument for the sole purpose therefor, as is the case in seacoast defenses; then, with height of instrument known, it becomes expedient to calculate in advance the distances or ranges which different angles of depression would indicate, and then to so construct the instrument that on observing a point on the water not the angular measure of the depression of the telescope will be indicated, but the corresponding predetermined range at once. In all the depression position finders now in use with our seacoast defenses such advance calculations have been made, but the mechanical means of indicating them are various.

The depression position finder now used consists essentially of a telescope, trunnioned horizontally at right angles to itself into branches of a vertical spindle, whereby it may be given any required direction, both in azimuth and depression. The intersection of cross-hairs in the telescope defines the line of sight that it may be precisely directed toward the target observed. Graduations on a horizontal circle fixed concentrically with the vertical spindle give the azimuths of the points observed, but the vertical circle of the ordinary transit instrument is absent, being supplanted by means for indicating the range direct, corresponding to the depression of the telescope. Were it not for the tides varying the height of the instrument, it would be theoretically possible to retain the vertical circle and to simply change the graduations from the degrees of arc to corresponding yards of range, for in any event curvature of the earth and normal refraction would be allowed for in the calculations, and abnormal refraction could receive the same correction in effect that is made for it in existing instruments, by simply moving the index mark at which the vertical circle would be read. But in practice the arc that would be used of the vertical circle would be too short to receive so many figures denoting ranges, and some mechanical means of multiplying the

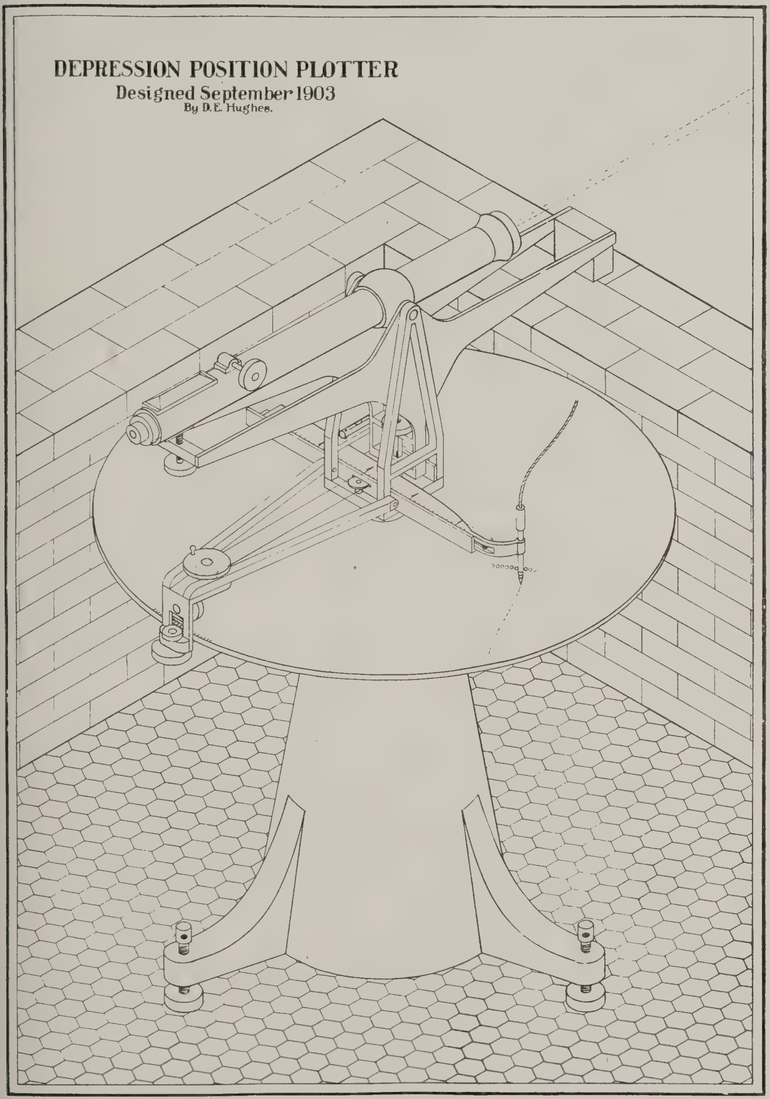
DEPRESSION POSITION PLOTTER
Designed September 1903
By D.E. Hughes.

Fig. 1.

motion to afford the room would be required. Besides, in tidal waters which make the height of the base changeable there would need to be different circles or else different graduations on the same circle for different heights of tide.

Instruments now in use have the depression of the telescope dependent on the height of a second point of support situated along the length of the telescope some distance from the trunnions, the height being capable of change and control by the operator. The distance of the secondary support from the trunnions is an inverse function of the height of instrument and admits of change to compensate for tides. The member furnishing the secondary support has a vertical travel too limited to afford room for graduation of ranges thereon, but the mechanism which changes the height also operates another member through wider limits sufficient for the graduations of the range scale. The above mechanism in all its parts travels nearly equal increments to give equal increments of angular depression of the telescope, but the latter gives very unequal increments of range, hence equal increments of range have unequal increments of movement of the mechanism and unequal intervals of graduations on the range scale, and there is nothing moving in existing instruments which could give proper motion to a pencil for plotting, for the pencil must move, to or from the instrument station on the map, distances which bear a constant ratio to the distances of the observed floating target from the instrument itself.

The ordinary procedure with instruments now in use is for the observer to keep the telescope directed toward the water line of the moving object, through its varying azimuths and ranges, stopping at stated periods for assistants to read the azimuth and range then obtaining, which azimuth and range are transmitted to other assistants to be received and plotted upon a map, thus giving isolated points to indicate the target's track, for the use of the commander who predicates his action thereon.

The proposed depression position plotter to be hereinafter described will, like existing instruments, give azimuths and ranges of observed points, to be read if required for any purpose, and in addition to that will, with a plotting arm, hold and guide a pencil to correctly mark upon a map lying horizontally beneath it the point or path of the intersection of the instrument's line of sight with the surface of the water.

The principal advantages of such instrument over those now

in use would be that need of all assistants between the observer at the telescope and the commander predicating his actions upon the plotted line would be avoided; that chances of error in reading azimuth and range and in transmitting, receiving, and plotting them would be eliminated; and that confusion would be avoided and silence could reign, much to the help of the average mind in making predictions and applying corrections. There would be still other advantages less apparent to the general reader, but appreciated by those experienced in this special work. A vessel may change her course between the last two points as now observed and plotted, so that the direction of her travel through and beyond the last point may be materially different from that of a straight line that would be drawn through the two points and produced to give the predicted position. By the automatic continuous plotting such change would be distinctly revealed, enabling one to predict the further course with greater precision. Moreover, after the prediction is made the pencil would be continually indicating the position of the vessel up to the last, so that in case of error in prediction or of departure from the predicated course or speed the officer could withhold fire, save ammunition, and make a new predication with the least loss of time. Another source of error in predicting a vessel's course beyond the last point observed and plotted, arises from errors in the observations themselves. The surface of the sea is often uneven. A wave may obscure the true water line of a vessel and indicate a false one to the observer at the instrument, and even in the absence of pronounced waves the surface of the sea may have gentle undulations of so long duration that an observer can not wholly eliminate their effects, and there will result a probability of error in any given observation and its plotting. Hence it may not infrequently happen in present practice that the last plotted point will be too far, and the one before it too near, or *vice versa,* whereby a straight line connecting them would have a direction materially different from that of the vessel's course, and thus lead to error in predicting her advanced position. But with the continuous automatic plotting such errors resulting from the unevenness of the sea would manifest themselves in waviness of the plotted lines, in which the vessel's true course could be judged with confidence and followed to the instant of firing. Especially important would this be when the enemy is entering a mine field, and one would give his life to have fired the right mine instead of the wrong one.

The invention of the depression position plotter, made in 1903, lies primarily in the thought of combining into one operation the observing of a point and the plotting of its position. The thought of having the position of a pencil so governed by the direction and depression of the telescope that the pencil must always point on the map to whatever the telescope points on the water.

The mechanical means of accomplishment, though not less necessary to success, are hardly to be called inventions, for, give to one possessed of mathematical ability and mechanical knowledge and skill an intelligent idea of a motion required and its accomplishment will be in one way or another effected. It is generally only a matter of time when divers ways of accomplishment will have presented themselves to have their relative merits examined, and it often becomes more difficult, rather than easier, to select the plan to use. But, in general, simplicity, stability, durability, directness of action and smallest number of parts are principal aims in mechanical design.

It is possible to design the mechanism to plot on a table removed several feet laterally, if need be, but more directness and simplicity are attained in having the plotting board underneath the observing instrument, with the map so placed that the instrument station thereon is in the axis of the spindle of the instrument or in a prolongation of such axis. The orientation of the map may or may not be the same as that of the instrument, as will appear further on.

For such position of the plotting table, the plotting arm would be supported and constrained by guides attached to the spindle or branches thereof to travel in azimuth with the telescope, and yet be free to move horizontally in and out lengthwise of itself in consonance with any changing depression of the telescope. The pencil would be so located at the end of the arm, or in a horizontal offset therefrom, that its path would always be in a straight line passing through the spindle's axis when the arm is moved radially without change of azimuth. Manifestly, the movements of the pencil in radial directions alone must bear a fixed ratio to the corresponding variations in the range of the target, or, what amounts to the same thing, the distance from the pencil to the axis of the spindle must bear a fixed ratio to the horizontal distance from the instrument to the target. That ratio will be the scale of the map, as 1-10,000 or 1-7,200, etc.

To devise and make the connection between the movements of the telescope in depression and the radial movements of the pencil,

that will give the constant ratio as above, requires some ability in computation and skill in construction.

Of the plans which have presented themselves, only a few will be outlined here. A comparatively simple plan would be to have one of the supports of the telescope bear directly or indirectly on the periphery of a cam fixed to a horizontal shaft, the form of the cam being such that the angular distance from the initial radius to any given radius shall bear a constant ratio to the range corresponding to the depression of the telescope when bearing on that given radius. Since the cam shaft, like the cam radii, would then revolve uniformly for a uniform change in range, the perimeter of a wheel fixed to the cam shaft would likewise travel uniformly and would give proper translatory motion to the plotting cam arm. The size of the wheel would depend upon the scale of the map and on the superior limiting range which it is desired to plot. The wheel and the plotting arm may be in or parallel to the vertical plane of the telescope and the plotting done either under the object end of the telescope, making the orientation of the map coincide with that of the instrument, or under the eye and requiring the map to be turned 180°. Or the wheel and arm may be at right angles to the plane of the telescope and the plotting done to one side on a map turned either 90° or 270° from its natural position. The latter arrangement would be preferred for the reason that one viewing the plotting and making predictions would not be interfering with the operations of the observer, and for the further reason that any deflection of the spindle due to the traversing of the plotting arm and the consequent shifting of the center of gravity would be in the directions that would not affect the accuracy of the ranges.

With the cam and wheel arrangement, the plotting could be in a room below the observing room if desired, for a downward prolongation of the spindle would give the rotary motion to the plotting arm, and the translatory motion would be conveyed from the wheel above to a similar wheel below by chain or bevel gearing. But the officer with the plotting board had better be with the observing instrument to insure better command of all.

The next plan to naturally occur is a simplification of the plan already described by omitting the wheel and shaft, and unrolling as it were the cam upon the upper surface of the plotting arm, thus making the arm a wedge with a curved upper surface for the telescope to bear upon. The vertical dimension of the wedge

at any given point of its length would be calculated to give the required corresponding depression of the telescope. The calculations, whether of cam or of wedge, would be based on the height of the instrument above mean sea level, and tides would be provided for by changing the distance between the fixed and movable supports of the telescope.

With a large table the telescope, to be within easy reach of the observer, might not extend to a point over the wedge. In such case it would be supported on an auxiliary frame which would extend not only as far as the point over the wedge, but some distance beyond, to support a counterpoise to overbalance the telescope.

The plotting arm would be graduated so that ranges could be read if desired. To the instrument would be hinged a light frame extending toward the observer to the periphery of the table, for use in revolving the instrument in azimuth, and for supporting a pilot wheel for translating the plotting arm, and to bear an index mark and vernier to give the azimuth if desired, which would be graduated on or near the edge of the table. The hinging of the frame, as mentioned above, would be adopted in preference to a rigid connection, in order that the spindle might not be deflected from the vertical in the event of any unevenness or drooping of the table.

The spindle passing through the table would not be in the way of any uses to be made of the plotting by either the mine commander or the battle commander; but under certain conditions, depending upon the relative positions of the instrument, target, and guns, it might interfere with the operations of a battery commander, for it might be in the way of the relocating arm used to determine the azimuth and range of the target with respect to a gun, as well as interfere with certain other appliances used in present practice. In some cases, however, when obstruction would be presented by the spindle it could be overcome by providing for it an offset in the relocating arm, or, if the gun be near the instrument, the center about which to revolve the relocating arm can be made so large as to embrace the spindle.

But to have the spindle pass through the table, though giving the simplest construction, is not a necessity. It may be entirely above, leaving the table clear, and have its bearings in brackets, yoke, or beam, supported by columns outside the table. The spindle bearing can be below the telescope but above the plotting arm, in which case the spindle would need be of large diameter and

hollow, to provide room for the mechanism controlling the depression of the telescope, and the field of survey would need to be narrow, for otherwise the beam would be in the way of either the observer or the commander, or both. The spindle bearing can also be entirely above the telescope in a beam high enough to give head room for all, in which case the spindle need be no larger than when passing through the table. The principal objections to having the spindle bearing above the table are that the cost of installation would be greater; that stability would be somewhat less; and that more work would be required in keeping the instrument level, since the two high columns and beam would be more subject to unequal temperature changes than is the single lower column now in use. However, these objections are not prohibitive, and in view of the advantages to the battery commander of an instrument that will do its own plotting, the objections may be waived.

Another mode of controlling the depression of the telescope by translations of the plotting arm and the one which, up to this time, is deemed to be the simplest and the best of all modes which have thus far presented themselves, will now be described with the help of the sketch (Fig. 1).

A T-shaped frame suspended and free to revolve about an axis passing through the center of its top and the top of the instrument's standards supports the telescope at one end and a counterpoise on the other of sufficient weight to overbalance the telescope and causes a constant tendency to increase its angle of depression and to swing the pendant portion of the frame toward the observer. This tendency is opposed by the foot of the pendant bearing horizontally against the curved front face of the wedge-shaped plotting arm which lies and moves horizontally at right angles to the plane of the telescope and its supporting frame. The back of the plotting arm is straight, bearing against a straight guide which is fixed with respect to the spindle. The width of the arm at any given distance from the pencil is such as to restrain the swing of the pendant and the accompanying depression of the telescope to that range which corresponds to the position of the pencil. The adjustment of the counter-weight is such as to cause only a light, but continued, pressure of the foot of the pendant against the plotting arm, and the design of the whole instrument is such that with the plotting arm in mid-position the center of gravity of all the weight borne by the spindle is in the axis of the spindle.

Whether the trunnions of the telescope in the frame coincide

with the trunnions of the frame in the standards, as in the sketch, is immaterial, and is dependent on the length of the telescope with respect to the table below. But in either case the trunnion support of the telescope would be removed, preferably toward the object end, from the center of gravity and a secondary support would be given the telescope by a vertical adjusting screw in the frame near the eye end. Such screw affords simple and convenient means of bringing the line of sight into proper angle with the pendant; also, for making such allowances for abnormal refraction as are made with instruments now in use. The same adjustments could be accomplished either by vertical movement of the cross-hairs in the telescope or by moving the foot of the pendant forward or back with respect to its leg, thus allowing the telescope to be rigidly fixed to the frame. But the independent motion of the telescope provided by its trunnion support is advantageous when, in searching for a target, it is desired to raise or lower the telescope quickly without translating the plotting arm. With the arrangement shown in the sketch the eye end may be lifted, revolving the telescope about its trunnions and off the supporting adjusting screw or it may be pulled down, revolving the frame about its trunnions and the foot of the pendant away from the plotting arm.

From the operating wheel, within convenient reach of the observer, motion may be communicated to the plotting arm by the use of either gearing or cords.

The instrument is proportioned in some of its parts to the height of station it is to occupy, and adjustment for tide is made by altering the length of the pendant by moving up or down the guided stem which bears the foot, and on that stem the tide scale is graduated. The plotting arm may be raised or lowered to correspond, but it is preferably left at a constant level, and its vertical dimension is made sufficient to allow for all up and down movements of the foot which bears against it.

The contact of the foot against the arm may be either a sliding shoe capable of universal motion on a spherical bearing or in gimbals, or it may be a vertical roller journaled into a frame which is cross-journaled into the foot of the pendant to permit the roller to always take a vertical position against the curved face of the plotting arm. With the first plan the surface of the shoe, bearing in a vertical line against the curved surface of the arm, can be a plane, which produced, would pass through the center of

the spherical joint which supports it, in which case the calculations for the curve are the simplest. With the roller bearing the curve would be different, being the envelope of a circle the size of the roller, having its center on the above primary simpler curve.

The pencil would be tight fitting in a metallic tube, which in turn would fit closely, yet move freely, in another tube rigidly attached vertically to the plotting arm. Thus the pencil would be free to rise and descend to accommodate itself to any unevenness of the plotting board and to give a constant pressure on the paper.

For some purposes for which the instrument is applicable, it is desirable to have the time intervals indicated on the plotted course of a moving target. This would be accomplished by the use of an electromagnet to either raise the pencil periodically, to make skips, or to tap it to make dots, operated by a special clock that would make or break the electric circuit at the proper times. Another means would be to use the table for one pole and the marking point for the other, and a sensitized paper that would be discolored by the passage of a current through it.

The remaining thought, and a most important one, is: Can the curved face of the plotting arm be so accurately made that the results will be satisfactory? There are mechanics with sufficient skill and patience, combined, to dress glass or hard metal to within one five-thousandths of an inch of the dimensions desired, and there are many who work to the nearest one one-thousandth of an inch, and it will appear later on that the latter, which is within a half of a thousandth of an inch of the truth, is sufficent accuracy to make the errors of results due to constructive defects smaller than are the usual and unavoidable errors of observation.

The sources of errors of observation are several. There may be as much as a quarter of a foot error in the observation of the tide, which, with an instrument 250 feet high, would be a thousandth part of the vertical base, and would cause errors of one part in 1,000 or 4 yards in a range of 4,000 yards. There is, also, usually a difference in height between the tide at the point where it is observed and the height obtaining at the target, which may increase the error unless there be a known fixed point near the target on which to make corrections. Ocean swells and waves also cause errors in instantaneous or short time observations, though their effects may be seen and allowed for on continuous plotting. Refraction, when abnormal, is so capricious that it can not be corrected for with confidence except in vicinities of known fixed

points. If the line of sight on its way to the water passes very close to the ground it may be, on a hot day, materially distorted vertically by so-called heat waves, resulting in errors.

Then why use the vertical base at all? But in practice the long horizontal base is not without its disadvantages, too. For there are the difficulties and confusion and time lost in identifying the target—that is, in making sure that both observers are viewing the same one of several targets. The additional lines of communication required add to the hazard that the work will be interrupted at a critical time. Two observers, howsoever faithful, will rarely ever give azimuths to exactly the same point on the target at the same instant in time—one's personal equation will be to follow the target longer than the other. In night work, which henceforth is likely to be most important, the difficulties are greatly increased, for with the use of searchlights a vessel may be plainly visible to one observer and present a dark side to the other. Hence, in practice, all things considered, the vertical base system with its minor defects is far superior wherever there is a sufficient elevation suitably situated for the work.

The calculations for the curved face of the plotting arm follow: The problem is to determine the width of the curved wedge at any given point, P, along its length as measured from the pencil. Let the telescope be level and the pendant plumb with the bearing point at its foot in the line of the axis of the spindle produced. The back of the wedge against the guide is at a given fixed distance, W, toward the observer from the axis of the spindle. Then for a depression of the telescope to any given range the foot of the pendant will revolve about the trunnions above toward the observer through an arc, the sine of which is the amount, c, to be cut away from the whole width, W, to give the width w of the plotting arm at that distance from the pencil which corresponds to that particular range, R. H is the height of the instrument *in feet* above the surface of the sea. R is the range *in yards,* and is the horizontal distance from the instrument to the target.

The height of the instrument above the *apparent* position of the target is greater than its height above the sea at its base by an amount equal to the correction for curvature for the distance, R, less the amount the target is apparently raised by normal re-

fraction, which latter is one-seventh of the correction for curvature. The correction for the earth's curvature in feet being

$$\frac{2}{3} \times \left(\frac{R}{1760}\right)^2$$

we have for curvature minus refraction,

$$\frac{6}{7} \times \frac{2}{3} \left(\frac{R}{1760}\right)^2 = \frac{4}{7} \left(\frac{R}{1760}\right)^2$$

and the height of the instrument above the apparent position of the target is

$$H - \frac{4}{7}\left(\frac{R}{1760}\right)^2$$

This augmented height and the range, "R," constitute the two legs of a right triangle which is similar to a smaller triangle at the instrument, of which the pendant, p (now inclined) is the hypothenuse, and C is the short leg and

$$\sqrt{p^2 - c^2}$$

is the other leg. Hence, the following proportion:

$$c : \sqrt{p^2 - c^2} :: H + \frac{4}{7}\left(\frac{3\ R}{5280}\right)^2 : 3\ R, \text{ giving } c = \frac{p}{\sqrt{1 + \dfrac{3\ R}{H + \frac{1}{7}\left(\frac{R}{880}\right)^2}}}$$

(Equation 1.)

in which c and p are in inches, H in feet and R in yards. If r be the distance in *inches* from the pencil to the point P, and S be the scale of the plotting, then

$$R = \frac{r}{36s}$$

(Equation 2.)

Substituting $\frac{r}{36s}$ for R in Equation 1 there obtains:

$$c = \frac{p}{\sqrt{1 + \left|\dfrac{r}{12\ s\ H + \frac{12s}{7}\left(\frac{r}{31680\ s}\right)^2}\right|^2}}$$

(Equation 3.)

which is the equation of the curve in rectangular coordinates, the origin being at the pencil and the axis of abscissas being the line passing through the pencil and the axis of the spindle. In this equation, for any given instrument, p, H, and s would be known quantities. Then, by assigning values to r the corresponding values of c would be determined. Or, Equation 1 may be used to determine the values of c to correspond with the different ranges.

In practice, the calculations can be much simplified and shortened by omitting, at first, consideration of curvature and refraction when Equation 1 would become

$$c' = \frac{H p}{\sqrt{H^2 + (3\,R)^2}}$$

(Equation 4.)

from which the approximate values of c would be easily obtained, and then applying to such values the scale of corrections for curvature and refraction, which corrections are, within the limits of R and H used in practice, sensibly proportional to the ranges. In other words, Equation 4 would determine the correct arm were it not for curvature and refraction, and to afterwards allow for these corrections only requires that the arm be made narrower at a uniform rate as the pencil is departed from. Such correction would be determined for one of the ranges, say 5,000 yards, by substituting the 5,000 in Equations 1 and 4 to get c and c', and taking the difference between them. Then one-fifth of that difference would be the correction for 1,000 yards, two-fifths for 2,000 yards, etc. As a rule, the width of the arm need not be calculated for intervals closer than 50 yards of range.

Dressing the curved face of the plotting arm can be obviated, if desired, by substituting therefor a flexible metallic ribbon held out to proper curve by a plurality of set screws in the body of the arm. The set screws can be properly set without the aid of micrometric measurements of the curve, if desired, by setting each screw in the field on the otherwise completed instrument so as to make the line of sight have that depression which would give the range corresponding to the position of the screw with respect to the pencil. This would be best effected, not with the use of a clinometer, but by making the line of sight pierce the proper predetermined graduation on a vertical post placed on the hillside a few hundred feet ahead of the instrument. Let the distance of the post from the instrument be D, and let the top of the post be

in the horizontal plane of the instrument, then the distance down on the post to the graduation corresponding to any range R, would be equal to

$$\frac{D}{3\,R}\left[H-\frac{4}{7}\left(\frac{R}{1760}\right)^{2}\right]$$

in which all measurements are in feet excepting R, which is in yards.

The longer the pendant the greater the accuracy that could be attained, but the wider and heavier would be the plotting arm. In practice, all things considered, lengths of between one and two feet would be most suitable. As stated before, the pendant must be adjustable in length on account of tides, for, as shown by Equation 1, if c and R be constant, p must vary nearly inversely as H. For any given tide the adjustment in length of the pendant will be practically the same for all the ranges. Though theory requires the curved face of the arm to be very slightly warped on account of tides, no sensible error will result from having all the elements of the surface parallel and plumb.

The truth of these last two statements is most easily shown from calculations made on a concrete case where the instrument proposed was to be 259 feet above mean sea level, and the tides to have an extreme variation of 5 feet above and 5 feet below the mean, and the ranges to extend from 800 yards to 4,400 yards, and where the length of the pendant for the mean height of 259 feet was chosen to be 15.54 inches. The results of these calculations are as follows:

No.	R, yards	H, feet	p, inches	c, inches
1	800	259	15.54	(1.66810)
2	2,600	259	15.54	(0.51820)
3	4,400	259	15.54	(0.30906)
4	800	254	(15.842)	1.66810
5	2,600	254	(15.844)	0.51820
6	4,400	254	(15.841)	0.30906
7	800	264	(15.249)	1.66810
8	2,600	264	(15.247)	0.51820
9	4,400	264	(15.249)	0.30906
10	801	259	15.54	(1.66604)
11	2,601	259	15.54	(0.51801)
12	4,401	259	15.54	(0.30899)

In the above results the parentheses show which of the four quantities in a line were calculated from the other three.

Comparing p in 1, 2, and 3 with p in 4, 5, and 6, and p in 7, 8, and 9, shows that the pendant would need to be extended .302-inch for a tide of 5 feet above mean sea level and shorted .292-inch for

a tide 5 feet below mean sea level. The near equality between the .302-inch and .292-inch shows that within the limits assumed, the tide scale graduations would be very nearly, though not quite, equidistant. They are sensibly equicrescent. The use of a longer pendant would simply magnify the tide scale.

The slight differences in *p*, as shown in 4, 5, and 6, also in 7, 8, and 9, indicates that theoretically the curved face of the plotting arm would need to be warped, but the smallness of these differences proves that within the ordinary limits of use no sensible error would result from having the elements of the curved surface all parallel and plumb.

Comparing *c* in 1, 2, and 3, with *c* in 10, 11, and 12, where the ranges are only 1 yard longer, shows that for 1 yard, at ranges of 800, 2,600, and 4,400 yards, the width of arm changes .00206-inch, .00019-inch, and .00007-inch, respectively. Hence, imperfections of workmanship on the arm, if confined within one two-thousandth of an inch of the truth (which is equivalent to working to the nearest one one-thousandth) would result in maximum errors of about one-fourth yard, two and one-half yards, and seven yards, respectively, in ranges of 800, 2,600, and 4,400 yards. If the imperfections of workmanship be reduced to one five-thousandth of an inch, which is possible of accomplishment, then the above limits of errors would be correspondingly reduced to about one-tenth yard, one yard, and three yards, respectively. The limits of instrumental errors vary as the squares of the ranges, being four times as great for 8,800 yards as for 4,400 yards. The errors of observation with this instrument would be the same as with the instruments now in use, easily amounting to half a foot of height in water lining, as before explained, which being in this case two-tenths of one per cent of the vertical base, would cause errors as large as 2 per cent of the ranges, or greater than the instrumental errors.

It appears therefore that it is perfectly practicable to make the plotting instrument fully as accurate as are the existing instruments which do not plot.

Since in the above figures the maximum, *c*, corresponding to the minimum range, is about one and two-third inches, and since at least one-third of an inch of metal would be required to properly support the pencil beyond, it follows that the straight back of the plotting arm and its guide would need to be in this special case two inches back of the axis of the spindle. From the total width,

here assumed at two inches, would be subtracted the computed values of c to get the proper widths of the arms.

It is an interesting fact that the pencil and telescope can be properly guided without any curve at all, but by straight line elements alone.

Referring to the diagrams below in elevation and plan, let F be foot of pendant when vertical, T is a fixed point which may be located, as will appear by Equation 7, anywhere on a certain equilateral hyperbola. A P is guide line through axis A of spindle at right angles to plane of telescope. P is the pencil. P T is a movable straight line sliding through T, and with its end, P, traversing guide line P A. Against line P T the foot of pendant bears at F′. Using the same nomenclature as before the elevation gives

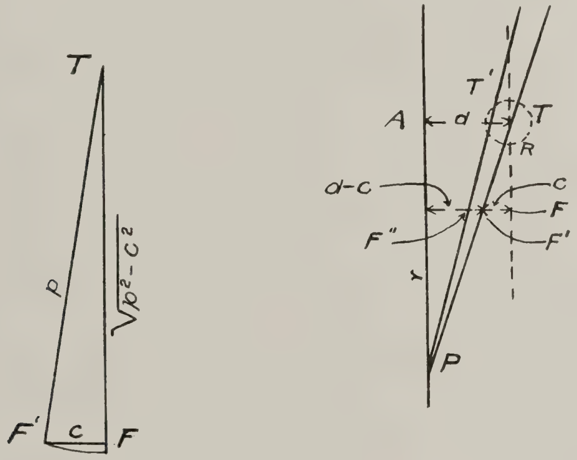

Fig. 2.

$$p:c::36\text{ R}:12\text{ H, whence } c=\frac{p\text{ H}}{3\text{ R}}$$
(Equation 5.)

and the plan gives

$$c:k::d:r=36\text{ R }s\text{, whence } c=\frac{k\ d}{36\text{ R }s}$$
(Equation 6.)

From equations 5 and 6: $k\,d=12\,p\text{ H }s$. (Equation 7.)

Let P=15.54 inches and H=259 feet, as before, and s=(1 inch=200 yards) or 1-7,200, then $k\ d$ would equal 6.7081, whence if k

be made 4 inches d would be 1.677 inches, or, k may be 3.354 inches, and d equal 2 inches, etc.

To provide for curvature and normal refraction, not allowed for in Equation 5, the foot of the pendant F′ will not bear directly on line P T, but at F″ against another straight line P T′ rigidly attached to line P T and making a slight angle with it.

Equation 5 also assumes R to be the inclined distance from the instrument to the target, which, in the case in hand, is greater than the horizontal range by 4.6 yards in 800 yards; 1.4 yards in 2,600 yards, and 0.8 yard in 4,400 yards. This could be corrected by having the pendant not of constant length, but telescoping so that its foot would travel only horizontally. Tide would then be corrected for by raising or lowering the contact of the foot of the pendant in the shoe or slide, which latter would traverse the line or rod P T only horizontally.

The advantages of this straight line plan would be the ease of manufacture and the fact that sliding contact could be surfaces of material width. The bearing at T would be a vertical cylinder journaled above and below and with one side of middle portion cut away in a rectangular notch reaching past its axis, in which notch the rod P T would slide.

But the disadvantages are that the point T would be difficult to adjust with sufficient precision, and that there would be a varying deflection in rod P T and in guide A P. And these disadvantages are so great that the substantial curved faced plotting arm with its constant rigid backing, though requiring patient, skillful handwork in its making, would be far more satisfactory in practice.

THE CHESAPEAKE AND DELAWARE CANAL IN THE CIVIL WAR

BY

Maj. R. R. RAYMOND
Corps of Engineers

During a very interesting lecture upon a totally different subject, the lecturer told of a magnificent masonry lock which had been constructed by the Government at considerable expense, and yet through which only one vessel passed each way daily. To him it appeared that Uncle Sam was extremely generous to the owners of this vessel. He passed on to other matters, leaving in the minds of his audience a distinct impression that the people had been forced to pay a large sum for the benefit of a few individuals, and that if only his wisdom had been possessed by the Government engineers, this wrongful waste would not have occurred. The lecturer was an able minister of the Gospel and therefore well qualified to pass upon problems in engineering and commerce.

There is a proverb that "They also serve who only stand and wait;" at least, that is the substance of it. The mere existence of that lock, standing there practically idle, but ready at any time to serve, was doubtless saving the people countless thousands of dollars day after day through its effect upon freight rates of other systems of transportation in the same section of the country.

The purpose of this very brief article is to suggest that the true value of a waterway is not always apparent, and to unearth an interesting bit of history which tends to show that even the military importance of such a highway is not invariably appreciated.

There is a small canal cutting through the backbone of the peninsula between Delaware and Chesapeake bays; its channel is of small dimensions and its length is less than 14 miles. A great majority of the people of the United States are unaware of its existence. High authorities have pronounced it to be of little military or naval importance; and yet someone must have recog-

nized the urgency for such a canal, else the herculean task of cutting such a great ditch through a ridge 100 feet high, by means of the primitive hand methods of a century ago, would hardly have been undertaken, nor would the Government and three States have contributed two and a quarter millions for the work.

In 1906, Capt. Phillip Reybold made an address on this canal at Wilmington, Del., and the following extract from his remarks sheds some light upon the matter:

> "On the 24th day of August, 1814, the battle of Bladensburg was fought, and the British, under General Ross and Admiral Cockburn, captured Washington, burning the Capitol, White House, and all the public buildings. The American people do not want that repeated. * * * It was this disaster that resulted in the building of the Chesapeake and Delaware Canal, and that is why the Government contributed $450,000 toward its construction."

The canal was completed in 1829, but as railroads were constructed and constantly improved its importance became overshadowed, and when the War of the Rebellion broke out it had been apparently completely forgotten by the military authorities at Washington. It was Captain Reybold's father, Capt. Anthony Reybold, who, being a maritime man, was well acquainted with the canal, and who, meeting by the merest chance and at the psychological moment an agent of the Federal Government, suggested at a time of great peril to the country the use of the canal so graphically described by Captain Reybold in the address mentioned above and quoted below:

> "On Wednesday the 17th day of April (1861), Virginia seceded from the Union and was starting her troops north to go to Washington. There was not a handful of troops in that city nor a breastwork thrown up, and the Federal Government started its troops south. You know what happened in Baltimore on Friday, the 19th of April, as the Sixth Massachusetts passed through, and that night every bridge on the Philadelphia, Baltimore, and Washington Railroad was burned from Baltimore to the Susquehanna River and totally destroyed, and the Federal Government had absolutely no means of transporting troops along the seaboard by rail to Washington; in fact, all land communication was severed.
>
> "On Saturday, the 20th, the Government seized all the propeller steamers in Philadelphia that could pass through the Chesapeake and Delaware Canal, and how well I remember that Saturday night as they steamed down the Delaware River and passed through the canal, and before daylight in the morning they were at Perryville, and just as the sun was peeping up over the horizon the

trains arrived at Perryville with the troops, where they were rushed on board of steamers and hurried away down the Chesapeake to Annapolis and by way of Annapolis Junction to Washington, and when that body of troops arrived at the Capital the Confederate outposts were at the Virginia end of the Long Bridge, and for the next sixty days this Chesapeake and Delaware Canal was the key to the whole Federal situation. The Potomac was closed by a series of batteries from Aquia Creek to its mouth and its waters were patrolled by a steamer called the *Page*, which the Confederates had converted into a gunboat. Suppose there had been no canal, what then would have happened? You would never have heard the cry of 'All quiet on the Potomac' going up, although you might have heard the cry of 'All quiet on the Delaware;' and the blood that soaked into Virginia soil would have been poured out in Pennsylvania and New Jersey. and reconstruction would have taken place in the North instead of the South."

Throughout the war this canal played an important, even a vital, part. Over it were transported reenforcements, food, clothes, ammunition and other stores, without which the Army of the Potomac could hardly have kept the field; and hospital boats carried back to the North wounded men who could have been moved in no other way.

Would it not seem that the name of this canal deserves a better fate than oblivion? Yet the suggestion is sometimes made that because it can not, with its present small cross-section and the necessity for charging tolls to maintain it, compete with the great coastwise rail lines and earn dividends, its construction was a mistake and its price wasted.

FUEL OIL *V*. COAL

BY

Mr. S. E. LAWRENCE
Assistant Engineer

COMPARATIVE COSTS FOR EQUAL EFFICIENCY

The oils on the Texas market and those available for use in this section, along the coast, are drawn from the Beaumont Humble, Spindle Top, Caddo, and other more local fields and from the Oklahoma districts as well. The latter, delivered here via pipe line, represent a mixture of most of the classes produced in that section, oils of both paraffin and asphalt bases being mixed with reduced crude in smaller quantities. The pure paraffin base oils in this mixture represent, usually, 10 per cent or less of the total, and the paraffin characteristics are largely lost in the much larger percentage of the prevailing asphalt base.

The local fields contributing to the supply for this market are the Goose Creek and Hoskin's Mound wells. The former has proved itself hardly worthy of consideration. The oil produced, while of a fair grade when separated, gives poor results from a heat producing standpoint, because of its inclination to hold water in suspension longer than other oils experimented with; it also contains much foreign matter.

The Hoskin's Mound product, while limited in quantity, is easy of access for certain plants and represents an ideal fuel, giving better practical results, considering all the desirable points, than any other oil used. This oil, being much clearer and freer from trash and sediment than the average oil, presents a distinctive greenish iridescence and has more the consistency and physical appearance of an engine oil than a crude product. It left very slight deposits of ash in the tubes when burned, this deposit differing from the ordinary soot in that it was much lighter in color and more easily removed from the tubes than the ordinary soot. While this oil was less rich in the more volatile hydrocarbons, its steam-producing power was not impaired; on the contrary, it was higher,

and on comparative tests with the ordinary oils an equal quantity supplied the required steam approximately 10 per cent longer time than others. This difference was due more to its freedom from foreign matters and to the fact that it deposited less soot in the tubes; the additional B. T. U's in the other oils being more than consumed by the extra quantity required because of dirty flues.

Owing to the uncertain components of the other mixed oils, the practical observations were of small value, as the locality from which it came could not be determined and no assurance being given that the mixture would be constant.

The results to be obtained from even the best oils to be secured are so directly dependent on the conditions of the individual boilers and furnaces that only approximate comparisons were possible in some cases. The furnace brickings and the exposure of the boilers to ranges of temperature had to be accounted for, the difference in firemen was also a factor. The main consideration, however, was the constantly varying steam requirements of the various engines on the dredges from which the practical observations were taken. Longer periods of time of oil consumption tended to equalize these variations, and a fair comparison was possible when allowances were made for different changes.

The individual conditions affecting steam production varied less on the sea-going dredges than on the more exposed boilers of the suction dredges and snagboats. Those on the U. S. dredge *Gen. C. B. Comstock*, a sea-going hopper dredge of about 600 cubic yards capacity working in a uniform material, gave exceptional opportunities for a comparison of the different oils from a heat-producing standpoint. It was the proposal to reconvert this dredge into a coal burner that incited a closer comparison of the Texas oils than the practical observations had given, and at the same time compare their relative heat-producing value with a standard coal.

The oils delivered in the Government tanks are handled in barges, which always introduces a possibility of more or less water being in the fuel, as very little oil is handled except in the holds of the barge and not in tanks. Owing to the large quantities required and the limited storage capacity on the Government oil wharf, a small amount of water had to be taken into consideration, as it was not always possible to allow time for settling. All "free water" was removed and did not enter into the estimates. By "free water," reference is made to such water as could be drawn off, and not to water in finely divided particles held in suspension.

The sampling was done by securing oils from different parts of the pipe line and tanks and mixing these; a sample of this blend being tested. Of the many different oils only the three most important ones were investigated to any extent; first, because of the inability of the Department to secure these oils in quantities and, second, because of their inconstant composition.

The three chosen for chemical analysis were the—

Hoskin's Mound Oil, as mentioned above;

"Beaumont Oil," so-called, a mixture from the fields centering at Beaumont, of fairly constant nature, mixed with reduced crude from the refineries;

Oklahoma Oil, the product delivered from the Oklahoma field through a pipe line.

Several determinations were made from each sample secured, and an average obtained from these for each individual oil considered. Other oils tested were eliminated from the general average, and conclusions drawn and comparisons made only from the above mentioned.

The data below represents results of averaged tests:

Oil.	B.T.U.	Specific gravity.	Flash point.	Settlings.
			Degrees F.	Per cent.
Hoskin's Mound	19,343	.922	204	1
Beaumont	19,640	.899	238	2½
Oklahoma	19,656	.892	91	----
Average	19,546	.904	177.7	1.16

The heat giving qualities of the three were fairly close together. The flash points show the widest variance; this very wide range being due to the almost total absence of the more volatile hydrocarbons in the Hoskin's Mound oil, and to the fact that much of the "Beaumont" oil was probably reduced crude. Other than being of interest, the determination of flash points has very little bearing on the fuel value, serving as an indication of the care that should be exercised to protect oils of low flash point from high temperatures. The specific gravity was fairly constant, but not an indication of fuel value.

The minimum B. T. U. requirement was placed at 19,500 for subsequent deliveries, and the specific gravity was allowed a rather liberal latitude—the limits being not less than .85, nor greater than .93.

The coal selected for comparison with the average oil was an average of run of mine bituminous coals, usually burned on vessels coaled in this section. These coals have a rather high percentage of ash. Twelve per cent for "dry coal"—*i. e.*, dried to 105° C. as prescribed by United States specifications. The short ton of 2,000 pounds, as used in the more recent and revised specifications for coal, was adopted, instead of the long ton of 2,240 pounds, as a basis of comparison. The unused percentage to account for waste and incomplete combustion was taken at 5.8 per cent, making a total of 17.8 per cent as the non-productive factor, entirely devoid of caloric value. This rather conservative estimate will appear more just when it is considered that oil properly fired is practically totally consumed, and if properly atomized it will not even produce a perceptible smoke.

With the limiting factors as determined above, a ton of coal represents an effective calorific value of 22,267,980 B. T. U's.

Considering the oil as being totally consumed, as it is under existing conditions, a barrel of 42 gallons, the unit ordinarily quoted on, would weigh (with specific gravity of .904) 316.4 pounds, and represent a heat value of 6,184,354.4 B. T. U's.

The calorific oil equivalent of one ton of coal is, then, 3.6 barrels. This, of course, is a local equivalent, all estimates being based on conditions existing in this particular section.

The cost of oils delivered in tanks at Government wharf is practically the same, irrespective of the kind and largely of the grade of fuel furnished. The supply is so well controlled and the output so readily consumed that very small competition is introduced. The prevailing price at present and it has been fairly constant for about two years, is $1.10 per barrel of 42 gallons delivered f. o. b. tanks.

To more justly regulate and adjust the price to the quality of oil delivered. a specification based on heat-producing qualities was introduced in the oil contracts, and a scale of price devised to conform nearer to the heat value of samples tested from each delivery.

In the provision for the fluctuation of the heat value, 19,600 B. T. U. was taken as a central standard and no deviation from price was made for a range of 100 B. T. U. either way.

Oil accepted, failing to fulfil specifications, is to be paid for in proportion to the B. T. U. it contained. Oils testing above 19,700 B. T. U. to receive a premium of .51 per cent of the market price

for every 100 B. T. U. over that amount, and a similar deduction of .51 per cent for all falling below 19,500 B. T. U.

Subsequent tests disclosed very slight deviations from the limiting requirements; the gravities always being close to the average, .904, and the calorific values also fairly constant.

Below are some of the results of tests on deliveries, made under the foregoing requirements:

	Barrels	Specific gravity at 15° C.	B.T.U.
May 7, 1910	----	.858	18,192 (1)
June 11, 1910	1,248	.907	19,782 (8)
June 13, 1910	1,238	.898	19,559 (6)
June 15, 1910	1,220	.905	19,501 (5)
June 24, 1910	1,525	.893	19,356 (2)
June 28, 1910	1,036	.933	19,670 (7)
July 1, 1910	1,017	.934	19,435 (4)
July 7, 1910	1,393	.910	19,433 (3)

No definite relation between specific gravities and heat values seems to exist, although it is the general impression among oil firemen and men actually in touch with fuel oils that a heavy oil, when free from water and dirt, gives best results. The above is hardly sufficient data from which to deduce correct conclusions, as in much of the oils received parts of its heat giving components had been previously removed.

The fact remained, however, that even under such a contract, the price of $1.10 was constant enough to use as a basis for the economic comparisons of oils and coal.

Eliminating all expenses incident to handling and burning coal in excess of those required for oil as a fuel, and considering their respective heat values alone, the following prices are equal for steam production:

Coal, per ton (2,000 pounds).	Oil, per barrel.
$3.60	$1.00
3.78	1.05
3.81	1.06
3.85	1.07
3.89	1.08
3.92	1.09
3.96	1.10
4.00	1.11
4.03	1.12
4.068	1.13
4.104	1.14
4.14	1.15
4.32	1.20

Considering the difference in operating with the different fuels, local conditions again are the determining economic factors. A large amount of water is used when the oil is atomized with steam. In

sections where plenty of cheap water is available, or when plant is operating in fresh water, this would hardly be of material importance, but boats and plants operating in out-of-the-way places, where long tows of water are necessary, make the atomizing agent a large item that should be taken into account when a change from one fuel to another is contemplated. If oil is used, the cost of maintenance of a compressor and its steam consumption are still larger factors.

Comparing the operations of the above-mentioned sea-going dredge, the *Gen. C. B. Comstock,* while burning coal and, later, burning oil, a fair idea was obtained as to the incidental costs incurred in the actual use of the two fuels.

The oils burned in this section are universally atomized by steam, owing to the simplicity of operation and the cheapness of water.

One fireman can easily operate two boilers, with two to three burners each, ordinarily requiring two men when coal is used; and, in some cases, three to four boilers are handled by one man, burning oil. It required five hours more time to coal up than it does to take an equal supply of oil aboard. Using the time that the full bunkers and tanks of one coaling or oiling up would operate the dredge as a unit, and estimating the additional cost due to extra loss of time and increased crew required, it was found that the cost of operating with coal would entail an additional cost that would permit the paying of 19.3 cents per barrel more for oil than the equivalent prices listed above—that is, burning coal at $3.60 per ton was as expensive as oil burned at $1.193 per barrel, equal amounts of steam being produced.

[TRANSCRIPT]

THE FINAL STRUGGLE FOR 203-METER HILL AT PORT ARTHUR*

(Reprinted by permission of the Royal Engineers Journal)

(Continued from PROFESSIONAL MEMOIRS, No. 9.)

December 2. During the night the enemy kept up an occasional artillery fire on the hill. At dawn this was increased, and the attacks by small parties were renewed, the events of the previous day being generally repeated. No serious attack was made, and no change took place in the condition of the defenders.

From Louisa Bay it was seen that the Japanese were moving about in the villages; under Visokaya increased energy was being put into the work of strengthening the defences; every sap and traverse was adorned with a fresh layer of sandbags, which were being brought up with this object in large numbers to the foot of the hill, and unloaded just above the lower parallels.

The Russians also increased their efforts at repairing their ruined works and making new trenches. It was decided first to put the trenches into good order, and afterwards to start repairing and unearthing the blindages. At this time Lieutenant-Colonel Organov was director, and Captain Veselovski was commandant, both belonging to the Twenty-sixth Regiment.

Tretyakov, after spending the night at the Fifth Regiment headquarters, went at 10 a. m. to the Ninth Hospital, where Dr. Krzhivets dressed and bandaged his wound, but did not remove the splinter, as he did not consider it harmful.

Kondratenko had returned to the Fifth Regiment headquarters at dawn, and awaited with impatience the return of General Tretyakov, which occurred at about 2 p. m. Taking him by the hand, Kondratenko overwhelmed him with enquiries about his health and about Visokaya Hill, and they continued to consult together until circumstances separated them, as it turned out, forever.

It was proposed to give Tretyakov rest for two days, but at about 3.30 p. m. Lieutenant-Colonel Organov reported that the firing on Visokaya was increasing and that he anticipated an assault, and as he himself was ill-acquainted with the hill and how to defend it with small forces, he begged that either Tretyakov or Irman, who were well acquainted with it, would ride up there to give him any necessary information and advice on the spot.

Organov was a very efficient staff officer; though brave, he did not feel confident that he could manage, in case of assault, the complicated problem of

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*Translation of an article by Staff-Captain Kostiushko in the March, April, and May numbers of the Eenzhenernee Zhoornal.

the defence of Visokaya Hill, and so he frankly asked men, whom he knew to be capable of it, to direct him in this difficult path.

Tretyakov at once got ready, and at 3.45 p. m. mounted his horse and galloped off to the hill.

At 4 p. m. ten separate 11-inch shells fell in the Tea Ravine, near the artillery barracks, where the reserve companies were quartered. This circumstance showed clearly that the Japanese could see well the whole Tea Ravine, and could correct their fire perfectly from the outwork which they had been at work upon the day before. As it was undesirable to expose the reserves to such danger, they were ordered to be removed from the Tea Ravine, and orders were also given to look to the safety of the Fifth Regiment headquarters, as the building was very exposed. But it was impossible to induce any of the staff to move at any time, because in the ravine they were near Visokaya Hill, could see what was going on there, and were consequently always in touch with their work. Therefore they contented themselves with closely veiling by night only the windows which looked toward the hill.

On arriving at Visokaya, Tretyakov found that Organov's fears were without foundation, but he remained on the hill, and decided during the night to find out accurately where the enemy was posted and in what force. For this enterprise more volunteers came forward than were required. Four men were selected by casting lots, and these, descending by the saddle on the far side of the hill, got as far as the trench which had been originally held, but which it had been decided on the 2d could no longer be occupied.

It should be mentioned that the covered communication trench having been demolished and all movement along it stopped, it became impossible to send assistance to the troops who were kept in this western portion of the ring trench, and consequently they all fell victims, at first to artillery fire and later in the unequal bayonet fighting, so that on both the 30th of November and the 1st of December the Japanese captured the trench with little difficulty. Seeing this, General Tretyakov, in order to save himself from devoting a fresh company each day to useless destruction, decided on the 30th of November to occupy this portion no more, and no harm had resulted thereby. The Japanese apparently did not occupy it either.

The reconnaissance party found the trench to be a complete wreck, the blindages broken in and presenting to view nothing but heaps of stones, splinters of beams and planks, torn sacks and other rubbish, mixed with fragments of human bodies.

They crossed this trench and went on down until they came to the Japanese parallel, which at this point they found to be empty. Wishing to decide whether the whole parallel was unoccupied or only a part of it, they turned to the right along it, but the Japanese began firing, and after this they could ascertain nothing accurately. Thereupon they climbed up again and went round the whole of the right half of the hill in the demolished trench without finding any Japanese. All four received decorations of the Military Order; they were all sailors belonging to Lieutenant Lavrov's æronaut detachment.

During the nights of December 2-3, 3-4, Ensign Ermakov was employed in making a communication trench up the eastern slope of Visokaya. The object of this trench was to protect reinforcements going up the hill from the Japanese artillery, posted in the village Shiushin, and striking Visokaya Hill in rear from

the northeast. Thanks to Ermakov's energy and the united efforts of Lavrov's æronauts, a trench 7 feet in depth was completed in the course of these two nights.

December 3. Having got such encouraging results from the reconnaissance on the right half of the hill, Tretyakov sent another four men to explore the left. Of this party none came back, a fact which was taken to show the close proximity of the enemy on the left flank, in trenches under the redoubt, though probably not in large numbers.

Wishing to relieve themselves of such undesirable neighbors, Tretyakov and Veselovsky decided to drive them out, and with this object they organized a small sortie. General Irman, who came up in the night to enquire into the state of affairs, approved of the undertaking, but, although a greater amount of success was to be expected from a large sortie, he was of opinion that it should be limited to a small one. This was because it would have been necessary to ask for reinforcements, and also for permission from the Commander-in-Chief for a large sortie, and even if permission were granted and reinforcements collected, the night would be past and all hope of success would have been lost, since in daylight no advance was possible; in fact, it was barely possible to hold on to what they had.

The volunteers selected for the sortie took with them a good number of grenades, and creeping near began throwing them at the Japanese, who fell back, raising furious cries and groans; the Russians advanced, but strong reinforcements for the enemy coming up the hill prevented them from completing their task. Yet not being thrown into disorder by this, and in spite of the overwhelming number of the enemy, they decided to make a fight of it, and met them with grenades and rapid rifle fire; the Japanese replied with the like, and about 5.30 to 6 a. m. a sharp firing broke out. The enemy were disturbed and, an hour earlier than usual, opened a terrific fire on Visokaya from all their artillery.

It is unnecessary to say that under such conditions the volunteers could do nothing, but had to retire suffering inconsiderable loss. But, in spite of its ill-success, this sortie was of very great value, as it disclosed exactly the position and strength of the enemy. It showed that the Japanese on Visokaya Hill were posted in great strength and complete readiness for action. It showed that from day to day and hour to hour it was necessary to await a desperate attack. But in connection with this sortie occurred the heaviest loss suffered by the Russians.

Tretyakov and Veselovsky were still uncertain of the results of the sortie, when between 5.30 and 6 there commenced a hot firing on both sides on the left flank of Visokaya. They at once stood up in their observation post and got ready for emergencies, but before they had time to ascertain what was going on a storm of every possible nature of shells burst upon the hill. In an instant the hill was in disorder—there was a pause. The reserves quickly ran up and dragged away the wounded who were near them. Another moment, and a huge shell had converted the whole observation post into a heap of killed and wounded. As the shell reached the hill, it struck the head of Captain Veselovsky, carrying away the upper half, and sprinkled those near, and especially General Tretyakov, with his brains. Then, striking the rock, it burst with a crash and caused a terrific vibration in the air. Splinters and stones struck

all those standing near and converted them into a heap of killed and wounded. In this heap Tretyakov lay insensible, and he was at once dragged down the hill, placed on a stretcher, and carried to the Red Cross Hospital. The distressing news spread on all sides like lightning. When he was carried past the headquarters, Fifth Regiment, he presented a ghastly spectacle. His pale inanimate face was covered with congealing blood and dust, his hands and clothing were blood-stained, and his gray coat was bespattered with brains. The bearers said that he was wounded in the head, and although he opened his eyes, he evidently recognized no one. All who saw him felt that his wound was mortal, and they went back to their work with heavy hearts, feeling that they could now bid farewell to Visokaya Hill.

In fact, the loss of Tretyakov was acutely felt by the whole garrison. His name was associated with success; both his seniors and his juniors put trust in his capacity, and in him was their hope. Both hope and trust were never disappointed, but every time strengthened.

From the evening of November 28, when he made himself famous by retrieving the fortune on Visokaya Hill, his name was everywhere mentioned with respect and pride. Since that date his series of brilliant deeds performed before the eyes of the rank and file had further enhanced his reputation. In fact, among the men he was looked upon as a demi-god, and the preservation of Visokaya Hill with such small numbers, in spite of the overwhelming artillery fire and preponderating numbers of the enemy, was attributed to his supernatural influence. This idea was developed automatically by the circumstances, in combination with the talent and character of this rare man. As an example of this, when most of the original officers had been killed and those who replaced them were entirely ignorant of the position, it became important to show the men that they were not uncared for, and consequently it was necessary to constantly visit and encourage them. This was naturally the work of their officers, but on Visokaya Tretyakov himself led them in their attacks, went round their trenches giving advice, orders, and information as to the state of affairs in neighboring sections, and in his quiet way, by kind words and by his presence at the most dangerous points, not only cheered the men and confirmed in them a sure trust in future success, but also inspired in them resolution and a thirst to take part in the most heroic enterprises. The men so venerated him that they prayed to God for his protection, and his fame extended beyond his own justly proud regiment, and beyond the defenders of the hill, to the whole garrison, and even to the inhabitants of Port Arhur. Tales of his exploits went from mouth to mouth and frequently passed into the realms of romance. Yet nothing was too wonderful to be believed by the men, who did not doubt that the hill was preserved by his influence alone, and felt such affection for him that they all, and especially those of the Fifth Regiment, wept bitterly at his loss.

In order to truly estimate the value of his services on Visokaya Hill, one must discard all fables and restrict oneself to the bare facts. Tretyakov arrived on the hill at a critical moment, when the greater part of it was in the hands of the Japanese, re-captured it, and for five and one-half days repulsed endless attacks without losing anything that could be considered a key to the position. From shortage of officers he had to do, besides his own duties, all kinds of subordinate work, such as practically leading each company in attack, directing the

work of the sappers, visiting rounds, encouraging the men, etc. In spite of fatigue, he never had time for rest. On the 2d, in spite of his wound, he appreciated the urgency of the situation sufficiently to remain at his post without asking for relief or rest.

In the fighting he displayed the qualities of courage, energy, activity, skill in influencing the men, and, from his engineering training, genius for putting his knowledge of fortification into practice. For every critical complication that occurred he always found some solution, and the more hopeless the appearances the greater were his coolness, activity, and courage. Only with the help of such qualities could the five major attacks (November 28, one; November 29, two; November 30, two) by overwhelming numbers of the enemy have been so brilliantly repulsed.

His exploits did not pass unnoticed by the enemy, and the deeds of the Fifth Regiment and its commander were frequently recorded in their gazettes. On the 6th of January, after the fall of Port Arthur, when toward evening the Fifth Regiment arrived at the 19th Verst ready to be entrained for Dalny, a Japanese major, who spoke Russian well, made many enquiries as to the whereabouts of the Fifth Regiment, and going up to the officers spoke in great praise of the whole Port Arthur garrison, and especially of the Fifth Regiment. In conclusion, he begged earnestly to be presented to ''the very gallant commander of the regiment.'' The Major's desire was granted, and he acknowledged himself very flattered by the acquaintance of such a brave Russian commander. At Nagasaki a deputation waited on General Tretyakov, and after many expressions of praise and enthusiasm, produced a gazette in their own language, in which his exploits were recorded.

General Kondratenko was greatly afflicted at the news of Tretyakov having been wounded. He said that he was ''invaluable'' and ''impossible to replace,'' and sent Dr. Troitsky to him with the following message: ''Give Nicholas Alexandrovich my deepest thanks for his valiant defence of Visokaya Hill, and express my sincere sorrow for his being wounded; say that a very great reward awaits him, and wish him a speedy recovery, for he is very necessary to us.'' It may be here mentioned that, in company with Stessel, Smirnov, and Irman, he afterwards received the Third Class of the Order of St. George.

Visokaya Hill having by these casualties been left almost without commanders, Lieutenant-Colonel Seifulin volunteered to go there, and having received the sanction of Generals Irman and Kondratenko, set forth immediately.

The Japanese artillery were shelling the hill with somewhat greater vigor than on the previous day, and their infantry continued to alarm the garrison with attacks made by small parties, but no resolute assault was attempted. They continued to push forward and worked hard at their entrenchments. The Russians also worked indefatigably at repairing their defences, but both sides found time for the interchange of rifle fire and grenades.

And so the Japanese rested for yet a third day, but the wearied Russians carried on the fight without relief or rest. In the majority of cases a company was told off to a trench, and remained in it until all were either killed or wounded. The men knew this, and it was very trying to their morale.

But for the successful defence of the hill efficient, and not exhausted, men were essential. This Kondratenko recognized, and therefore he sought for an arrangement by which companies could be relieved every two days. At the

same time, he made up his mind that the garrison of Visokaya should consist solely of companies of the Fifth Regiment. This decision is intelligible when it is understood that the companies of the Fifth Regiment were receiving praise at all hands, and in view of the probability that after their rest the Japanese would renew their more powerful attacks, it was necessary to be prepared to meet them with the best and most trustworthy troops of the garrison.

But a very material obstacle impeded the carrying out of this intention. All the companies of the Fifth Regiment had carried on without intermission the fights on Visokaya, Flat, and False hills, and were tired out, besides having suffered enormous losses. Some of them numbered only 20 men each, including the wounded, who had remained in the ranks. Besides this, most of the officers had fallen. But the desire to form the garrison of the hill from companies of the Fifth Regiment was so great, the idea so tempting, that Kondratenko decided to bring these companies up to strength, and as there were no reservists available, he did this partly with hospital men and partly with a draft of 213 men of the Twenty-eighth Regiment, which was sent up for this purpose, under Sub-lieutenant Gudkov. This combination at first sight appeared very suitable, but complaints had been made against the hospital detachments, and the stoical, trusty companies of the Fifth Regiment would have preferred to have been made up without them.

Orders were also given to repair the shortage of officers by appointing the best of the Fifth Regiment non-commissioned officers as acting ensigns.

In this way about 600 men, chiefly hospital men, were drafted into the eleven companies. About 20 of the best non-commissioned officers were made ensigns, and thus the regiment again possessed officers and an average of 100 men per company.

When distributing the hospital and Twenty-eight Regiment men, the companies were brought up to approximately the uniform strength of 100 each. Where more of the original men remained the hospital men were in a minority, but in the companies which numbered only 20 of the original men the result was not satisfactory. The hospital men did not serve willingly under the officers and under ensigns they worked still less willingly. Where there were comparatively few of them they were influenced by the majority, but in the companies where they were four times the stronger party they were difficult to manage.

The Second, Third, Fourth, and Sixth Companies were the first brought down from the hill, and when they had been made up to strength, they were sent to the barracks to rest.

Kondratenko personally met the decimated companies, and shook hands with, and in some cases kissed the newly appointed ensigns, praying the men to love and obey their new commanders. He cordially thanked the men for their courage and congratulated those who had distinguished themselves, decorating 10 men in each company until the supply of crosses was exhausted, and when there were no more left, noting down names for future rewards.

About midday, Dr. Feodor Semenvich Troitsky arrived with the joyful news that Tretyakov's wound was not serious. Everyone rejoiced at the good news. On further enquiry, he explained that the General was wounded in the neck, eyes, face, back, badly bruised by the ''wind'' and by stones, and crushed by the heap of killed and wounded who fell on him.

Besides the wounding of their commander, the 3d of December brought fur-

ther irreparable losses to the Fifth Regiment, as on that day both Captain Stempnevski I. and Staff-Captain Belozerov died of their wounds.

Stempnevski had on the 30th of November been wounded by several splinters; one hit him in the back and lodged in his lung. In the hospital his wound was probed, but the splinter was not found, and he was unnecessarily exhausted. He gave every hope of recovery; on the evening of the 19th of December he took a bath, got into bed almost unaided, and then lay asleep. During the night he began to breathe heavily, and at dawn was gasping for breath, and then died quietly.

Belozerov was wounded on the 29th of November by a splinter from an 11-inch shell in the head, which formed a large wound, but his brain was little damaged; as he lay in the Ninth Hospital he at times came to himself and talked. His comrades were delighted and hoped that he would recover, but for this he required good nursing, and there was none at that time in the hospitals. A very limited number of servants and assistant surgeons had been left, and no Sisters of Mercy were obtainable, the rest of the attendants having been drawn from the ranks. For this reason Belozerov did not get good nursing. He soon became delirious, and in one period of delirium, falling out of bed to the floor, he struck his head and did not recover consciousness, but died in about two hours.

As a means of repulsing the threatened assaults, Kondratenko asked two naval officers to make an attempt to establish on Visokaya Hill a mining apparatus, and to fire from it into the Japanese saps. On the evening of the 3d of December these officers and a few sailors with the apparatus went to the hill and long searched for a convenient spot sheltered from the Japanese shells on which to put it up; but they were finally convinced that no such spot existed, and were obliged to return without carrying out their object.

December 4. During the night of December 3-4, Lieutenant Kalmin succeeded in getting a 6-inch gun of 120 puds (4,333¼ pounds) to Pigeon Bay, and in mounting it secretly in front of the quick-firer entrenchments of Staff-Captain Sirtsov. His intention was to strike the flank and rear of the Japanese during their expected fresh attack on Visokaya Hill, and in the course of the day he fired a few trial rounds. During the whole night the enemy kept up occasional artillery fire on the hill. At dawn the fire increased and attained the same proportions as on the previous day, and at the same time weak infantry parties kept annoying the garrison. Both sides carried on entrenching work with increased activity, and the whole day they kept up firing and bomb-throwing.

Movements of Japanese toward Visokaya Hill were noticed from Pigeon Bay and from other parts. And so, while the enemy rested and collected large reserves, the Russians had to wait prepared for the attack.

General Kondratenko and Colonel Semenov rode up to the Fifth Regiment headquarters and consulted with General Irman concerning Visokaya Hill. While arranging for resting the rank and file, Generals Kondratenko and Irman showed equal consideration for those in command. In Order No. 39 of the Western Front of the Land Defence, two reliefs of commanders for Visokaya Hill were detailed as follows: In the first, the director of the hill was Lieutenant Colonel Organov and the commandant Lieutenant Ivashchenko, with Sublieutenant Rafalovich as his assistant, all three being of the Twenty-sixth Regiment. In the second relief, the director was Lieutenant-Colonel Butusov,

of the Frontier Guards, the commandant Captain Solonikio, Twenty-seventh Regiment, and his assistant was Ensign Kraushvili. The second relief took up the duties at 11 a. m. on the 4th of December. At about 4 p. m. the Second, Third, and Fourth Companies, Fifth Regiment, set out for the hill. They had all passed a night in barracks, and all had been made up to strength with hospital men. They were commanded by Ensigns Foshin, Kondratiev, and Moskvin, respectively.

As it was intended that these companies should be relieved on the next day, it became necessary to get a fresh draft of the Fifth Regiment ready, and for this purpose the Ninth, Tenth, and Twelfth Companies were recalled from Flat Hill. They numbered altogether about 100 men, but in the course of the night they were made up with hospital rank and file and dismissed to rest in barracks, with strict orders to sleep out the rest of the night, but at the same time to be ready at the first summons to come up to the headquarters, Fifth Regiment—surely a rather complicated task!

To replace losses among the officers of the Fifth Regiment, Stessel sent up Sub-lieutenant Gudkov and Reserve Ensign Semenov. Gudkov arrived on the evening of December 4 and took over the Sixth Company, Fifth Regiment.

During the 4th, Naval Lieutenant Lavrov, commanding the Aeronaut Detachment, was mortally wounded. Owing to the great losses which had been suffered on the right peak from artillery fire, part of the Aeronaut Detachment was sent to the spot, and Lavrov went with it. General Irman being on the hill, and not wishing to lose a good officer without special necessity, said to him, ''You had better not go; I will find you some other employment.'' ''No,'' answered Lavrov, ''where my 'swallows' go, there I go too,'' and he went off with his party.

At this time the right peak was under fire from machine guns and occasional shrapnel. The sailors quickly reached the trench which had been allotted to them and began to take their places, Lavrov standing up to his full heighth to attract their attention. Suddenly a shrapnel burst within four paces of him and he fell. The first of the sailors who ran to his aid was killed by machine-gun fire, but others lifted up their beloved commander and bore him to the dressing station.

December 5. At dawn Lieutenant Kalmin opened fire on the enemy, who had during the night crowded into all the trenches, approaches, and shielded places on the western slope of the hill. Several very good hits were observed, especially in the portion of the Ring Trench occupied by the Japanese, as after each a crowd of the enemy was seen to break away and run in the direction of Angle Hill.

When they tried to advance over the open in dense masses, Lieutenant Kalmin's shells fell in the midst of their columns and on the very sky-line of the hill, which checked their advance and compelled them to move by small parties in rushes along approaches which they hastily built up with sandbags.

Their artillery also opened an answering fire, but as they did not see the 6-inch gun they directed their fire on Sirtsov's quick-firing gun position, so that the latter could be no longer occupied. Kalmin fired in all 98 shell and greatly assisted the defence.

On this day the observations from Pigeon Bay gave less useful results than hitherto, because the Japanese made use of their approaches and did not ad-

vance in the open. Thus to the observers it frequently appeared that no advance was in progress, and yet the terrible artillery fire on the hill, which raised clouds of dust and further impeded observation, left small doubt that something very serious was going on there.

What really happened was that from 6 a. m. the Japanese artillery began sweeping the hill with every nature of shell fire, and their now-rested infantry harassed it in the most persistent manner. At this time the posts of director and commandant were held by Butusof and Ivashchenko, respectively.

Kondràtenko reached the Fifth Regiment headquarters at 7, and Colonel Semenov arrived some time later. Between 8 and 9 a. m. the companies in reserve were expressly summoned to headquarters, at first the Sixth and Twelfth, later the Ninth, and finally the Tenth Company, Fifth Regiment. The men had had no rest, as the Tenth Company had only got in at about 3 a. m., and the Ninth Company only about an hour earlier, and it had taken a long time to reorganize them and complete them with hospital men before breaking off.

Between 10 and 11 a. m. the Japanese began to attack the hill, at first with small parties, and later on with larger ones. The Russian losses from artillery fire had been considerable, and the enemy had some success on the left flank. Alarming reports began to come in from the hill, and as these arrived so the reserve companies were sent up; but as the Tea Ravine began to be swept by Japanese rifle fire, the advance of these companies was delayed, the men having to go by ones and twos, and in places by rushes. In consequence of this, they only reached the hill about midday. Up to then nothing serious had occurred, except that the enemy had got into the left redoubt.

The Sixth Company, Fifth Regiment, under Sub-lieutenant Gudkov, which arrived before the rest, was sent by Butusov to make a counter-attack on the left flank of the hill, while Butosov himself with Ivashchenko set to work to reorganize the retiring parties of riflemen. The Sixth Company, going up by the communication trench, moved rapidly against the Japanese, led by Gudkov, who set a fine example of courage, and by his dashing conduct compelled the Japanese to fall back. After this, heavy firing continued for a long while; the Japanese bombarded the hill with every description of shell, especially shrapnel, they swept it with the fire of rifles and machine guns, threw hand grenades, and occasionally cast mines. The Russian riflemen replied chiefly with grenades, and partly also with rifle fire, but they preferred grenades, as many of their rifles had become blocked by the dust thrown up by the heavy artillery bombardment. Lieutenant Gudkov went the round of his men and encouraged them, joining in the fight with his revolver. After a time he was wounded, but remained on duty directing the action of his (Sixth) company, into the ranks of which many men from other companies had now become mixed, until he received a second wound and was rendered unconscious.

Meanwhile, the Japanese waited patiently. Lieutenant-Colonel Butusov used every endeavor to hold the hill up to the arrival of Lieutenant-Colonel Organov, who was better acquainted with the ground. The latter was due at 11 a. m., but for some reason was delayed. Butusov, ill acquainted with the ground and exhausted by his night's work, sent frequent telephone messages, urging his despatch. These were passed to Irman, Kondratenko, and Colonel Semenov, but at 11.30 a message was received with news that he was dead. He had been mortally wounded, and only survived his wound for a few hours.

Captain Ivashchenko, now left in sole command and appreciating the precarious state of the hill, collected some odd men and a party of newly arrived riflemen, and led a counter-attack against the left redoubt; but he was wounded in the right leg and carried to the dressing station. After this, Lieutenant Agafonov was appointed commandant. He had recently taken over the command of Fort No. 5 from Ivashchenko.

Kondratenko was very uneasy while Visokaya remained without a commandant, and he urged Agafonov to get there as quickly as possible. The latter started at once from Fort No. 5, and, to please the General, took a short cut, which, however, led him astray, and a long time passed without his arriving at the hill. Kondratenko, nervous and anxious for its fate, at about 12.30 appointed Captain Solonikio to be commandant, Lieutenant-Colonel Pokrovski to be director, and, as assistant to Lieutenant-Colonel Seifulin, who was keeping order in rear, Captain Pobilevski. These appointments were made at the headquarters, Fifth Regiment, and a considerable time elapsed before the officers arrived at their posts.

After Ivashchenko was wounded, for some time the sole command on the hill rested in the hands of Acting Ensign Abramov, Fifth Regiment, who encouraged the men by the example of his personal courage, and besought them to hold on stoutly until assistance should come up; but owing to the large numerical superiority of the enemy a certain amount of ground was lost.

Meanwhile, the companies of the reserve, which had been sent from the headquarters at 10 a. m., came straggling up, and Lieutenant-Colonel Seifulin, who was posted to preserve order under the hill, appointed the senior of the new arrivals, Staff-Captain Sazonov, commanding the Twelfth Company, as temporary commandant of the hill.

Sazonov forthwith set to work to organize a counter-attack against the Japanese, who had taken possession of half of the left redoubt. This attack he superintended and led forward himself. At first all went well; the bravest men in the companies crept forward with grenades in their hands, and fairly soon gained the crest of the left redoubt. Gorielikov, a gallant young noncommissioned officer of the Twelfth Company, led the way, and the rest of the rank and file followed, with their company commanders well to the fore. The Japanese began to fall back. The counter-attack, in spite of the terrible fire and preponderating force of the enemy, promised full success, when unfortunately, Sazonov fell insensible from a blow on the head from a stone or splinter. Almost at the same moment Lieutenant Sirotko, commanding the Ninth Company, was wounded in the head. Deprived of their commanders, the men lost confidence. They did not fall back, but distributed themselves in the recaptured works, and carried on a grenade fight with the Japanese, holding on to the hill as best they could up to between 3.30 and 4 p. m.

At about 1 p. m. Lieutenant-Colonel Organov arrived at the headquarters, Fifth Regiment, and immediately set out for Visokaya. Kondratenko saw him, and prayed him to use every endeavor to preserve the hill. The telephone at that time was not working, because the connecting leads had been cut by Japanese shells. Reports were being sent by mounted volunteers, and were delayed accordingly.

At about 1.30 to 2 p. m. Irman rode up to the hill, and on his return reported to Kondratenko how things stood, and that everything depended on

the sending up of fresh troops. At about this time a party of sailors arrived, and were immediately sent on to Visokaya. The urgent need of a reserve forced Kondratenko to draw four more companies from the Eastern Front and the center, and also to beg for two companies of sailors from the General Reserve.

Just then things began to go badly on Visokaya; the artillery fire found many victims, and the groups of Russian soldiers grew thinner and weaker. At 3.30 in the afternoon, the Japanese advanced to the attack in dense masses. From the weakness of their numbers and the want of reserves, the Russians were able to offer little resistance, and the Japanese easily captured the left redoubt and part of the saddle, while in other parts the fight went on stubbornly.

At about 4 p. m., from the headquarters, Fifth Regiment, it could be clearly seen with field glasses, and even with the naked eye, that the Japanese had gained the crest of the hill, especially on the saddle, and were fighting the Russians with grenades, constantly advancing toward their left front—that is, from the left redoubt toward the right.

The telephone was again working, and each report from the hill became more alarming than the last. These reports took the form of conversations, and may be summarized as follows: ''The Japanese are advancing; they are pressing us back; the position is critical; reinforcements are necessary.''

The last officially appointed commandant of the hill, Captain Solonikio, fell about this time, though no details of his fate are forthcoming; and after him the command passed from one to another, until at 4 p. m. the rôle of commandant, in fact, that of practically the whole charge of the defence of the hill, appears to have been held by Naval Engineer Losev, who had several times gallantly distinguished himself in the previous fighting. Thus, for example, on the 28th of October, having collected some 20 volunteers, he advanced to drive the Japanese from one of the trenches which they had occupied. There was about a company of the enemy present. Coming upon their flank, Losev threw a grenade, and the Japanese, surprised, rushed to one side, whereupon the volunteers leaped into the trench. Without allowing them time to recover, he advanced in front of his men, throwing grenade after grenade,and pressed back the enemy step by step, until he had cleared the whole trench. After easily carrying out this and other comparatively straightforward tasks, this gallant sailor now found himself in a position of extreme difficulty, as he was called upon to assume the sole command of Visokaya Hill at a desperate moment, when with a terribly thinned line of six companies, in all about 300 men, he had to oppose three whole regiments of attacking Japanese. Little skilled in the fortifications, in the duties of commandant, and in the complicated defence of the hill, he felt small confidence in himself, and sought for a man who might help him with advice on emergency. But by this time all the officers had fallen, and only by chance he found Sub-lieutenant Gudkov, who, having been wounded at mid-day, had lain for some time in an unconscious condition on the crest of the hill, until he had been picked up by the men and carried into the telephone blindage. After someone had hastily dressed his wounds, he remained lying in the blindage waiting for a stretcher, and getting a little warmer he began to feel better. At about 4 p. m., when the overwhelming strength of the Japanese was clearly evident, in order not to fall

into their hands, he decided to wait no longer for the belated stretcher, and was preparing to crawl to the dressing station when Losev, approaching the blindage for the purpose of holding a conversation with the Fifth Regiment Staff, stopped him and appointed him his assistant.

''Of what use can I be?'' asked Gudkov.

''You, as senior infantry officer, can help me with your advice,'' answered Losev. ''Lie as you are, only do not leave the hill until another commandant arrives to take the place of Solonikio, so that in case of necessity I may have some one to consult with.'' Gudkov agreed, and remained lying in the telephone blindage.

Meanwhile, things were going from bad to worse. The small handful of Russians who remained on the hill was melting away with alarming quickness, and having no power to withstand the dense masses of the Japanese, was falling back step by step.

While reporting the critical state of affairs, the commandant begged for either reinforcements or orders as to what he should do. At this time reserves with all haste were moving from the Eastern Front and center, and some companies were already arriving at the headquarters, a fact which was communicated to the hill. ''Hold on a little, reserves are already arriving,'' was passed to the commandant; but the Japanese would not wait, and at about 4.30 to 4.45 he reported that the Japanese, having taken the left redoubt, were sweeping with fire the hill and its slopes, had taken the saddle, and were strengthening their attack on the right redoubt, in the maintenance of which no hope remained. In addition to this, they were spreading over the top of the hill; the nearest of them were within 10 to 15 paces of the telephone blindage, and would soon cut it off and break the telephone connection. He begged permission to move down under the hill and take the telephone with him. In reply to this Staff-Captain Baum, Chief of the Staff of the Western Front of the Land Defence, in the name of General Irman, did not sanction the removal of the telephone, and ordered him to defend the hill to the last.

A few minutes later, from the Fifth Regiment headquarters, they tried to ring up Visokaya Hill, but no further answer was received. And so the last time that Visokaya Hill spoke on the telephone was at about 4.30 to 4.45 in the afternoon of the 5th of December.

Taking into consideration the state of things on Visokaya Hill, Generals Kondratenko and Irman, Colonel Semenov, and their Chiefs of Staff, at 5 p. m., held a consultation in the headquarters, Fifth Regiment, and decided at the approach of dark, i. e., from 6 p. m., to bombard Visokaya simultaneously from all the forts and entrenchments, and then to attack the Japanese with the fresh companies and drive them off. Orders were accordingly sent to all the forts and entrenchments of the Western Front to open fire with all their guns on Visokaya Hill, exactly at 6 p. m.

The First Foot Volunteer Detachment, Fifth Regiment, which was now commanded by the newly appointed Acting Ensign Lavrov, was again summoned from Entrenchment No. 4. It had not been made up with hospital men, and numbered about 50 men. The command of the attack was entrusted to Lieutenant-Colonel Organov, and for general supervision General Irman also rode up to the hill within a few minutes of 5 p. m. At 5 it began to get dusk, and by 6 almost complete darkness enwrapped the belligerents.

On the 5th of December, in the afternoon, the Japanese also carried out an attack against Flat Hill, and again seized part of the Russian trenches, but were then driven out, on this occasion by one of the Hospital Detachments.

After Irman had ridden off from the headquarters, Fifth Regiment, to Visokaya, Generals Kondratenko and Nikitin continued to watch the fight through their field glasses. There was also present General Tserpitsky, Inspector of Hospitals, who had come over to look into arrangements in the section under attack. General Tserpitsky immediately set out for the foot of Visokaya to look after the preservation of order in rear.

As Kondratenko thought that the men would obey a general officer more readily than a newly appointed acting ensign, and that even the presence of a general would make a favorable impression on the troops, he begged Nikitin also to ride up to the hill, and consequently the latter, in company with his aide-de-camp, Lieutenant Uspenski, went off soon after General Tserpitsky.

At this time the reserve companies moved up the Tea Ravine, the men going by rushes, either singly or in groups. In order to stop them the Japanese, having seized almost the whole crest of the hill, opened a terrible rifle fire, and now and then shells also came flying over. All movement in the ravine became extremely difficult and dangerous. Many who were wounded while passing through it came back again, but the dead were left lying in this ill-fated ravine, as there was no time to collect them.

Not more than a quarter of an hour after he had left the Fifth Regiment headquarters, Uspenski, aide-de-camp to General Nikitin, was carried back on a stretcher, wounded in the left side below the heart.

Irman had started at 5 p. m. on horseback, accompanied by two orderlies. Bullets whistled overhead and fell alongside him, but he rode on quickly, entirely in the open, presenting an excellent target to the enemy. About half way his horse was wounded in the neck, and a second time in the mane, but hard ridden he continued his gallop until a third bullet, which raked him full length, breast, kidneys, etc., knocked him over. Irman succeeded in jumping clear, and an orderly flew to the horse, but immediately fell dead.

''Shall I kill it?'' asked the other orderly, taking his place.

''No, take it back and have it attended to,'' answered Irman, and went on on foot to the hill.

After the General, a Sister of Mercy, Mme. Krik, drove up in a pair-horsed ambulance, and had just got down when the horses, frightened by the firing, from which one was wounded, turned and started back again full gallop, taking with them the driver, scared, and wounded in the leg.

A few minutes later an hospital cart came up and stopped under the hill; seated by the driver was General Tserpitsky, who, as he began to get down was wounded by a bullet in the leg. A rifleman ran to his assistance, and with the driver lifted the wounded General (who was at this time again wounded by a bullet in the head) from the cart. He was carried to the dressing station in an unconscious condition, and Sister of Mercy Krik dressed his wounds.

Carts loaded with cartridges and grenades drove rapidly to the hill, and rarely did one get through without having either driver or horses killed or wounded.

Meanwhile, advancing by rushes, the reserve companies drew near to the

hill. Captain Pobilevsky received them. In advance of the rest there came up a company of sailors from the *Bayan*, and by 6 p. m. the following:

A company (probably the Ninth), Twenty-fifth Regiment, under Sub-lieutenant Soloviev.

A company, Fifteenth Regiment, without an officer.

Half of the Sixth Company, Twenty-sixth Regiment, under Ensign Golubev.

First Foot Volunteer Detachment, Fifth Regiment, under Ensign Lavrov, and apparently one more company, of which details are wanting.

The newly arrived companies were very weak (30 to 35 to 50 files), and the First Volunteer Detachment numbered only 50 men. In this way the force under Irman, although considerably strengthened, did not exceed from 800 to 1,000 men, and was too weak to retake Visokaya Hill, now occupied by eight battalions of Japanese.

To take command of companies which had no officers, Lieutenant Agafonov, Twenty-sixth Regiment (who was detailed to the company of the Fifteenth Regiment), Lieutenant Sinkevich, Sub-lieutenant Nechay, Twenty-seventh Regiment, and others also arrived at the hill.

At 5.30 p. m., Kondratenko, having discussed matters with several artillery officers, and having ascertained that the Russian artillery through want of shells could not do much good, but would rather do harm, as it would force the retirement of any of the men who might by chance be holding out upon the hill, and besides that, judging that the extra time would enable the Japanese to entrench more strongly the part which they had occupied, altered his decision to attack the hill, after first bombarding it with artillery from all the forts, and sent word to General Irman by mounted orderly not to wait for the artillery preparation, but to attack Visokaya as soon as the reserve companies should come up. Orders to cancel the firing were sent by telephone to the various forts and batteries, but probably these new orders did not reach them all in good time, because at 6 p. m. some of the forts, entrenchments, and batteries opened fire, all the same, on the very top of the hill; in the absence of definite information they supposed that the Japanese were on every part of it. The fire was not marked by good mutual combination, because only certain of the works were firing, and consequently it did no good; but, on the other hand, a handful of men who were apparently holding on to the right peak, and a group of the Second Company, Fifth Regiment, under Ensign Fomin, who were still maintaining themselves on the left flank of the Ring Trench, and who had had no orders or information, on seeing that the Russian artillery was shelling Visokaya, concluded that the hill had been finally abandoned, and retired.

In doing this, Fomin found that he had to burst through the Japanese outpost line on the southern slope (left flank) of the hill. The Japanese apparently had no suspicion of the presence of any Russians on the hill, because they were all looking keenly, and also firing, in the other direction, *i. e.*, toward the Tea Ravine. As it was already quite dark, Fomin collected together the remnants of his company (10 men), and after he had fired a volley into the enemy and thrown his last grenade into a column which he found in rear of them, which sent them rushing in alarm to one side, he rushed through with his men and happily reached False Hill, and eventually Tea Ravine.

Here the men were unable to take part in the firing, because of the condition of their rifles; all were choked with dust, the greater number were quite unserviceable, and the rest could be used only very slowly.

The retirement of the party on the right peak was carried out entirely without incident.

In this way the whole summit of Visokaya fell into the hands of the Japanese, who now dropped their shells on the rear slope and the foot of the hill. These shells fell exactly where the men of the newly arrived companies had been with so much difficulty assembled and got into order and arranged by companies. While carrying out this work Lieutenant-Colonel Seifulin was wounded by a bullet in the arm, and was taken to hospital. The troops that were under the hill, and also their commanders, now knew that the Japanese had taken the whole hill, and the riflemen retreating from the right peak, by the news which they brought in, confirmed their doubt in future success, and threw a clearer light on the existing state of affairs.

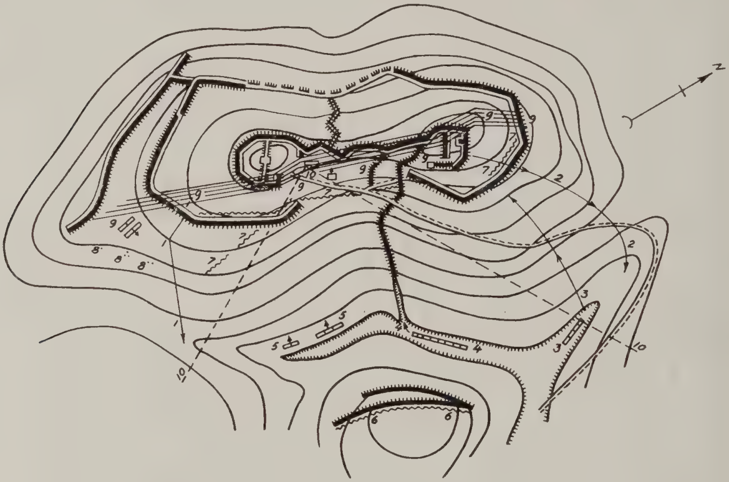

Fig. 9. Visokaya Hill. Position of the combatants at 6 p. m., December 5.

1. Position and line of retirement of 7 to 10 men, Second Company, Fifth Regiment, under Ensign Fomin.
2. Line of retirement of last group of men from right redoubt.
3. First Foot Volunteer Detachment, Fifth Regiment, and the line of its attack.
4. Center column (advanced along the covered approach).
5. Left column.
6. Third Section, Eighth Company.
7. Japanese outpost line.
8. A few individuals and small groups of Japanese.
9. Line of Japanese reserves.
10. Japanese machine gun, showing its arc of fire.

Just after this Irman received the order for the immediate attack of Visokaya Hill, and with Organov, Pabilevski, and others, began to discuss the final arrangements. A large shell burst near this group, and the force of the explosion threw them from their feet and covered them with stones; but impressed with the gravity of the situation, they continued the consultation. It

was decided to divide the force into three parts, and to move one against the right peak, the second against the saddle, and the third against the left redoubt. The right column was to consist of one company, the center of two companies, and the left of one and a half.

By this time it had become almost pitch dark, and the newly appointed company commanders, knowing neither their men nor the ground, were in a position of great difficulty. The newly arrived companies, unacquainted either with the groud or with their new commanders, were crowding together without confidence, while the Japanese dropped shell after shell at the foot of the hill and their infantry kept up a continuous rifle fire. All this added considerably to the difficulty of organizing the attack, but in spite of it the advance took place at about 6.30 p. m.

The First Infantry Volunteer Detachment was detailed for the attack on the right peak, the company of the Fifteenth Regiment, under Agafonov, and half of the Sixth Company, Twenty-sixth Regiment, were told off to the attack of the left peak, while the *Bayan* company of sailors and the company of the Twenty-fifth Regiment, under Soloviev, attacked the saddle. Each man was ordered to take with him two or three grenades, and they were encouraged to take more, as great reliance was placed in these weapons.

Fig. 10. Result of attack of General Irman, carried out at 6.30 p. m., December 5.

1. Line of advance of the right column (First Foot Volunteer Detachment, Fifth Regiment). The portion of the redoubt occupied by them is shaded.
2. Section under Sergeant Kibikin.
3. Center column. } Shown in their most advanced positions.
4. Left column. }
5. Third Section, Eighth Company, Fifth Regiment.
6. The thick line shows the limit to which the Japanese were driven back.
7. Japanese machine gun.
8. Arc of fire of machine gun.

The companies, encouraged by General Irman and other officers, and formed in column by the right, moved boldly forward, the center column passing along the communication trench, which had been recently made by Ensign Ermakov.

Between the left and the center columns there advanced the Tenth and the remnants of the Second, Third, Sixth, and Twelfth Companies, Fifth Regiment, and between the center and right columns the remains of the Ninth and Fourth Companies and others.

The Japanese met this attack with a terrible fire. Every available weapon was brought into play; a machine gun, which they had succeeded in posting on the saddle near the left redoubt, and which brought a cross-fire to bear on the whole slope traversed by the Russians, began to crackle, together with rapid rifle volleys; bombs were thrown, and the Japanese artillery directed all the fire of their artillery on the slope and foot of Visokaya Hill. Death filled the air, and at each step the killed and wounded rolled over in heaps. In spite of this, Irman, with Organov and Pabilevski, continued to clamber up the hill. It was evident that they had decided to conquer or die.

The hillside was covered with killed and wounded, but the living continued to move forward. The Volunteer Detachment on the extreme right flank, in spite of the terrible fire—they were fortunately covered from the machine gun by the northern slope of the hill—and suffering enormous losses, quickly climbed the hill, reached the right peak, and attacked it without delay. Charging with the bayonet, they succeeded in retaking half of the right redoubt.

In this success the Volunteers were greatly assisted by Sergeant Kibikin, who had taken command of the remnants of his Ninth Company after Lieutenant Sirotko had been wounded, and who also quickly climbed to the right peak, and by his supporting fire and successful grenade throwing in rear of the Japanese, who were being attacked by the Volunteers, forced them in spite of enormous numerical superiority to fall back. For this act Kibikin was recommended by General Kondratenko to be promoted to the rank of ensign and to be decorated with a gold cross; but because he was not so rewarded on the spot, he is still a non-commissioned officer and wears no cross of the Order of St. George.

The success of this attack was also partly due to the fact that Irman himself assisted in its immediate superintendence, and encouraged the men by his personal example. The *Bayan* company was one of the first to scale the hill, but its commander was unfortunately wounded, and after this the men lay down in the path which led to the telephone blindage.

The gallant company of the Twenty-fifth Regiment also pushed forward under Sub-lieutenant Soloviev, an officer whose deeds of valor had come especially under the notice of Kondratenko, and who, outstripping his comrades, gallantly climbed upward with his company, and reached the road to the telephone blindage, in fact, very nearly the top of the hill. Then, without waiting, he set to work to drive out those Japanese who were posted there and on the saddle, when he fell severely wounded in both legs by a grenade, and was carried to the dressing station, and subsequently to the headquarters, Fifth Regiment. Here General Kondratenko had a long talk with him, asking many questions about the state of things on Visokaya, and promising to reward his gallant actions with the Order of St. George. His company, after it had lost its commander, also lay down approximately along the line of the road and opened fire.

The Tenth Company, Fifth Regiment, was now commanded by Sub-lieutenant Borodich. This officer, who belonged to the Twenty-eighth Regiment,

had been sent to take the place of Staff-Captain Astafiev, who was killed on the 30th of November. He became highly popular with the men, who would do anything for him. In their ascent, climbing over heaps of killed and wounded, they reached the same road, leading up from the telephone blindage. At this point gallant Borodich was killed, to the great grief of his men, who also lay down here and opened fire.

The left column rushed forward up the hill with the utmost gallantry, but coming under very heavy fire, they lost Lieutenant Agafonov, killed, and Ensign Goluber, wounded, and lay down on the slope a little more than halfway up. After they had lost their commanders, the men lying on the exposed slope also melted away under the cross-fire of the Japanese. The corpses lay in heaps, and among them lay the survivors. Groans, the crackling of machine guns, and the explosions of shells and grenades filled the air with all kinds of noises, in which the voice of one man was completely lost. While keeping up their rifle fire, the men saw nothing but the dark silhouette of the hill and the flashes of the fire directed at them, heard nothing but the echoes and whistling of every possible form of deadly danger, and could only try more closely to crouch against the slope, which provided no cover, and which was being so appallingly swept with shells, grenades, and the bullets of rifles and machine guns.

All the efforts of Irman, Organov, and Pabilevski to make these companies get up and move forward were unavailing. After despatching Organov to the headquarters, Fifth Regiment, to make a personal report of the state of affairs to General Kondratenko, Irman went down the hill, and finding there a large crowd of stragglers, he set to work to organize them into a single unit, with which he might support the companies lying on the hill and carry them forward. But he found this plan very difficult to carry out; some of the stragglers, through bad food, hard work, nine days' uninterrupted fighting, and other ills, were quite exhausted; others, from wounds received in previous fighting, were maimed and quite unable to mount the hill, and finally a third lot, having survived the horrors of the fight, had become moral cripples, and of all were the least fit for fighting.

Such was the state of affairs on Visokaya Hill at 8.30 p. m., when Irman, desiring an interview with Kondratenko at which he could personally explain the causes of his failure, handed over the command to Captain Pabilevski and set off for the Fifth Regiment headquarters.

General Kondratenko, rapidly losing hope of recapturing the hill, was suffering severely from the disappointment, when Irman arrived and reported approximately as follows: ''The men are extremely fatigued and can not climb the steep slope; they crawl a few paces and then stop to take breath, and consequently their attack has no vigor and they suffer enormous losses. The stronger men move forward more quickly than the weaker ones, but almost all of them have fallen under the terrible fire from the hill. Besides this, it is extremely difficult to direct the attack, it is so dark that nothing can be seen. From the explosions of shells and grenades, from the crackling of the Japanese machine guns, from the rifle fire, the shrieks of the wounded, and the cries of the combatants, the noise on all sides is so great that commands are not heard. The men are so keen on firing that nothing will stop them; it is necessary to shout orders to each man in his ear. The greater part of each company has

fallen, and the survivors, collected together in groups, lie flat on the slope and fire. Unfortunately, hardly anyone knows the ground; there are no officers—all have fallen. But in spite of all difficulties I led the men three times to the attack and obtained some success in places. But for complete capture of the hill the force is utterly insufficient; we require at least eight fresh companies more.''

Having no spare companies at his disposal and unable to abandon the hill, Kondratenko was dissatisfied with the report, and after asking Irman several questions, he wound up the interview by saying: ''Do you wish me myself to lead the companies to the attack? Ride off there and attack again!''

Irman answered, ''It shall be done,'' and turned to leave; but the officers present at headquarters detained him for a minute. Well knowing the reckless bravery of General Irman, no one doubted that after this order he would go to certain death, and with no possibility of obtaining success, he would do his best to return no more. To each one it appeared certain that he saw Irman for the last time, and each tried to calm him and to persuade him not to sacrifice his life quite uselessly. M. Sliunin, the priest of the Fifth Regiment, who was present, took an ikon and, blessing the General, hung it round his neck outside his sheepskin coat.

He then set out for Visokaya Hill in company with Captain Gobyato, and found the conditions unchanged. The road to the telephone blindage was in several parts brightly illuminated by the woodwork of blindages and other works having been set on fire by the explosions of shells and grenades. The companies, now much thinned, were still holding the slopes in groups and carrying on rifle firing.

Irman and Gobyato collected some of the stragglers and led them up the hill. The Japanese, noticing the movement, reopened a terrific fire, increased now by the fire of yet another machine gun.

Captain Gobyato, urging on the men, started up the steep slope, but had only got about half-way up when he was hit by a bullet in the mouth and lower jaw, and went back to the dressing station. Irman, now unattended by an officer, went in the open up the slope, and gathering together from various parts a few handsful of men, led them to the attack, throwing himself with drawn saber in front of them, but found that he could do no good. It is astonishing that he should have remained uninjured. His orderlies were wounded, and his *gens d'arme,* though twice wounded while doing his duty and accompanying him, remained with his General until a third wound finally laid him low.

On his way from the dressing station to the hospital, Captain Gobyato called in at the Fifth Regiment headquarters and explained in writing, for he could not speak, to General Kondratenko, the state of affairs on Visokaya. His opinion was that every one in Port Arthur must be sent at once to the hill, or that it should be abandoned while it was yet dark and the Japanese could not see the weakness of the force attacking them.

At any rate, to attack an enemy eight times stronger, and occupying and entrenched in a position of such strength as Visokaya Hill, was a matter of great audacity, to which the Russian troops had gone only on the strength of the brilliant results of their counter-attacks on the preceding days, and because the Japanese had acted without confidence.

The reports which were brought in by mounted Volunteers were short, delayed, and sometimes entirely lost. Consequently, it was necessary to apply to the wounded officers who were brought in from the hill, and most of the ininformation received was obtained from this source. This information was very unfavorable and left little hope of success, but Kondratenko was unwilling to believe it. How many times already had they survived alarms on Visokaya? How many times had he lost all hope and sent one or two companies in haste, rather to cover a retirement than to support an advance, when he had received the entirely unexpected news that the hill was re-captured? In his heart he was awaiting yet once more news of success.

But after he had received Gobyato's report, he decided to call a council of war, and summoned first Lieutenant-Colonel Organov, and later General Irman also, to explain the existing state of affairs. After hearing from these others reports to all intents similar to that of Captain Gobyato, he said sadly, ''Now begins the death agony of Port Arthur,'' and then after a short silence he sent round to summon the council.

A table was put into the room, which previous to the fighting had been occupied by Colonel Tretyakov and Lieutenant-Colonel Seifulin, and which had previously been a model of neatness and cleanliness, but was now deserted and disordered, with unnecessary rubbish thrown about the floor. On the table was unrolled a large plan of the fortifications of Port Arthur, and around were arranged a stool and a few benches. In the center sat General Kondratenko, with Colonel Semenov by his side, and the rest sitting or standing round the table in two rows, irrespective of ranks. Irman and Organov had returned to their troops under Visokaya.

The state of affairs was briefly as follows: From all places where men could be withdrawn without actual danger every one had been taken, and had perished on Visokaya Hill. Of those who remained, there were insufficient to reoccupy and hold the hill unaided. Besides this, they were extremely exhausted by the ten days of uninterrupted fighting, and could hardly move.

The Japanese were quite firmly established on Visokaya, and at the same time carried forward their attacks on the center and right flank of Arthur. No one doubted that their main objective was Visokaya Hill, and that the other attacks were merely demonstrations; but it was quite impossible to make use of the companies in the attacked areas. It was necessary to hold on at least to what was not yet lost.

After informing those present of the existing state of affairs, Kondratenko put a question in this form: ''Can anyone give a suggestion as to how Visokaya Hill can be preserved?'' After some silence, various remarks were heard, from which the general opinion was clearly shown that, with a sufficient number of fresh troops and with complete artillery support, it might be possible, but such resources were not at their disposal. To the question ''Is it not possible to save Visokaya with available resources?'' all present, fearing to grieve their already saddened comrades, merely shrugged their shoulders. The spirit of hope and confidence which had existed up to the 30th of November was now changed to despondency and apathy.

At first General Kondratenko wished to adopt the former method of saving the hill, *i. e.*, by bombarding it with the artillery from the forts, and again attacking it with all available forces; but then he hesitated and renounced this

plan, for the reason that the artillery, through want of ammunition, gave no hope of success. An example lay before us. At 6 p. m. the artillery had fired, but it had given the infantry no assistance. Added to this, at any rate on the right peak, the Volunteers were somewhere holding on, and it would not do to risk shelling their own men.

"And so, gentlemen, no one can propose a way of preserving Visokaya Hill?" said the General, casting a lingering glance around those present; and when he had recognized that this was indeed the case, he decided to abandon the hill, and put forward the following question: "What position shall we now occupy, *i. e.*, shall we hold Flat, False, and Division hills, or retire to the line of the original position, between Forts Nos. IV and V, including Red and Fougasse hills and the New and Two-Angled lunettes?"

Here followed a short but animated interchange of opinions, from which it was decided that the second position was the more suitable, because with the fall of Visokaya the strength of Flat and False hills had been lost, as the near distance and the great command of the first gave to the Japanese the power of raking their trenches, and of observing each yard of their defences, with a view to attacking at a favorable moment. The whole of the Tea Ravine was clearly seen from Visokaya, and all passage along it of provisions, cartridges, grenades, or reinforcements in the daytime must be finally put a stop to. Further, if the Japanese by a successful attack should occupy these hills by daylight, the garrisons retiring along the ravine under fire from Visokaya must inevitably be destroyed; and it was surely a mistake to risk whole companies where men were so short.

But the main advantage of the second position lay in the fact that it was only half the length of the other and gave the power of saving several companies. Its fault lay in the trenches, blindages, and other works, which were greatly inferior to those erected with so much trouble on Flat and False hills, and which had not as yet been completely destroyed by the Japanese artillery. But this fault was not a serious one, since the distance of the Japanese trenches from the new position was at least a verst, while from the old position it was only some 50 to 70 paces; and while the Japanese were advancing over this distance the Russians would have considerable time to improve the condition of their works.

And so it was decided to occupy the position from Fort No. IV, through Two-Angled and New lunettes, and Fougasse and Red hills, to Fort No. V.

Orders for carrying out this decision were sent at about 11 p. m. to the various companies. Division, Flat, and Fougasse hills were to be evacuated during the night, and all necessary stores were to be brought to the new position, every precaution being taken that the enemy should not notice what was going on. In order that the Japanese should not advance into the Tea Ravine before dawn, and by doing so upset the plan for occupying the new position, General Kondratenko sent Lieutenant-Colonel Zubov to take command of and reorganize the troops under Visokaya, with orders to hold back the Japanese at all costs the whole night and retire at dawn, after demolishing all works which had not yet been wrecked by shells, and which might be serviceable to the enemy.

Irman and Organov started back on their way to the headquarters at about 10 p. m., and Pabilevski remained in chief command under Visokaya. At this

time there was a distinct lull in the firing, and the gallant Sub-lieutenant Nechay, Twenty-seventh Regiment, who was commanding several companies of the Fifth Regiment, noticing this weakness of the Japanese, decided personally to satisfy himself as to where they exactly were, and in what numbers.

In vain did Pabilevski tell him not to do this, and with three or four Volunteers he started on his rash reconnaissance. He crept to the top of the hill and stopped before the low parapet of a newly completed Japanese trench. Cautiously raising his head, he began to look around, and the Volunteers did the same. Just then the Japanese began to fire; Nechay's forage cap flew high into the air, and he and two of the Volunteers remained motionless while the rest crawled rapidly down.

Shortly after this Pabilevski was appointed to the command of the newly occupied original position, and he was recalled to headquarters to receive his instructions. Lieutenant Sirotko, who was lying wounded in the dressing station in a blindage, took his place, pending the return of Irman and Organov; but he did not hold the command very long, as the others soon returned, and at about 1 a. m. Lieutenant-Colonel Zubov also came up to superintend the retirement.

Each of the companies posted on Flat, False, and Division hills, on receiving instructions for their retirement to the new position, was divided into two parties, one of the uninjured men and the other of the remainder. The able-bodied half-companies were at once loaded with stores, and under the command of non-commissioned officers started for the new ground, while the rest, with the company commanders, remained to guard the trenches.

At about 1 a. m. the able-bodied men reached their new positions, deposited their stores under guards, and at once returned, so that at about 2 a. m. the companies were again at full strength. Then in each company from 12 to 20 Volunteers were chosen to cover the retirement. These men were to remain in the trenches for about an hour after their company had left, and extended in a thin line were to fire and throw grenades at the enemy, so that he should not discover the retirement. At about 3 a. m. the companies left their ruined trenches on Flat, False, and Division hills, and at about 4.30 the Volunteers also retired.

That the retirement was entirely unnoticed by the Japanese is shown by the fact that, in their official report of the occupation of Flat Hill, it is stated that the Russians posted there could not hold it under the fire from Visokaya and from other points, and were obliged to retire, and that in consequence of this the hill was occupied by them at 1 p. m. on the 6th of December. There is no mention of the occupation of False and Division hills in the report. This shows that they were taken still later; in fact, it was not till about 2 p. m. on the 7th of December that, after a powerful artillery bombardment, they attacked Division Hill and took it without loss.

On the 7th of December Sub-lieutenant Galileev, Fifth Regiment, with volunteers from his own (Eleventh) and the Eigth Companies, carried out a sortie from Red Hill against False Hill, and found that the side of it facing the Russians was unoccupied, while the other side was held only by a picket.

The companies posted under Visokaya Hill waited till dawn on the 6th of December, and then retired in good order to the original position, covered by Volunteers and by the units which had suffered less seriously than the rest.

The Japanese could not have failed to notice the retirement of these last detachments, but they contented themselves with pursuing them only with rifle fire.

During this day, the 6th of December, Naval Engineer Losev and Sublieutenant Gudkov, with a wounded rifleman and a telephonist, were taken prisoners in the telephone blindage on Visokaya. It will be remembered that at 4.45 p. m. on the previous day Losev had reported by telephone the critical state of affairs, and had begged permission to leave the hill and carry down the telephone, but had received orders to hold on. Meanwhile, the Japanese had already reached the blindage and dropped down into the approach leading to it. Fearing that they might get into the blindage and make use of the telephone to listen to orders from the Russian staff, Losev barricaded himself in the blindage, hoping to get out again when the hill should be retaken. But this did not take place. All night long bullets and splinters of shell whistled past, machine guns crackled, and hand grenades burst on it or near it, threatening to set it on fire. By dawn the sounds of firing receded, and it became evident that the Russians were retiring. They consulted together as to the best way to escape, and decided to wait for the night, hoping that in the darkness they might succeed in slipping past the Japanese, who were moving about near the blindage and over the whole hill. Unintentionally they all went to sleep, and were thus captured.

On this day, also, a wounded rifleman came in, and stated that he had remained after the rest had retired in the dressing station, where he had been found by the Japanese, who treated him kindly and dressed his wounds, and one of their doctors had spoken to him in Russian. He said that the Japanese were all laughing; probably they were delighted at the capture of the hill.

On the 7th of December, at dawn, two riflemen came in from Visokaya, and said that by a miracle they had escaped injury in a ruined blindage, and subsisting on biscuits, were waiting to be dug out, when they found that the fighting on the hill was finished, and that Japanese voices were heard on all sides. Using their combined efforts to enlarge the opening of a loophole, after about twenty-four hours work they made it large enough to climb through. Going cautiously down the hill and taking the direction of False Hill, they nearly ran into a Japanese picket, but thanks to the loud talking of the Japanese soldiers, they discovered it in time, and turned in the direction of Tea Ravine. When they had avoided the last Japanese post, they got up and began to run. A dog ran after them and the Japanese fired a few shots. but did not follow them. They were the last to leave Visokaya Hill.

RESULTS

When they had taken the hill, the Japanese established an observation post on it, from which they were able to correct the fire of their 11-inch guns on the fleet, and in the course of three or four days they sank all the battleships which had taken cover under the land defences in the inner roadstead.

The Russians saw with pain and disgust the shameful destruction of their fleet. One after another, large and small, they were struck and foundered in the shallow waters of the inner roadstead, now called sarcastically the ''Haven'' or ''Mouse Trap.'' Only the gallant commander of the ironclad *Sevastopol*, Captain Essen, not wishing to expose his ship to such a fate, took

her into open waters and moved to the outer roadstead of the White Wolf. Almost daily did the Japanese throw 11-inch shells at this ship, right over Arthur, and almost nightly they attacked her with torpedoes, in which they sometimes lost torpedo boats; but it was not till the end of December that they so wounded her that there remained nothing for her heroic crew but to sink her. Then Essen took her out in 150 feet of water and sank her. An heroic resistance; and even the very fact of sinking her where he could rely upon her total loss encouraged the land garrison and drew great sympathy toward her crew.

The Japanese, observing from Visokaya Hill everything that went on in the New Town, were able practically to stop any movement about the streets by daylight. They also fired by night; but this firing was only at random; while by day they threw shrapnel from guns posted on Visokaya at every passing wagon and cart, every group of men, and even at individual passers-by.

Besides this, the hill played an important part as an observation post in the attack on Forts Nos. II and III, Entrenchment No. 3, and the Great Eagle's Nest.

Tactically, in Visokaya Hill the Russians lost and the Japanese gained the strongest of all the temporary defences of Port Arthur, a commanding height and key to the Western Front, and in some opinions, to all Arthur. The loss of Visokaya was especially felt by the works of the Western Front, which it took in flank and rear at short range, as, for instance, Fort No. IV. Besides this a direct road into New Town—the Tea Ravine—had been thrown open to the enemy. *Morally*, the fall of the hill had a very depressing effect on the garrison, and greatly encouraged the Japanese.

The men now posted in new positions, which were neither naturally nor artificially notable for their strength, instead of engaging in cheerful conversation, kept their eyes sadly directed against the threatening, depressing form of Visokaya Hill, covered with the black craters of 11-inch shells, like the festering sores of some terrible illness. They did not fail to see the importance of the position and the power of its works. They recognized that every effort had been used in the struggle for its defence, and that each man, sparing neither life nor strength, had loyally done his best, had fought to the last, and yet the enemy had conquered—evidently, he was stronger than they!

The conversations on such occasions sometimes turned into grumbling against those in command, who, when Flat, False, and Division hills were abandoned, had forbidden the men to set fire to the uninjured buildings and stores which were left behind. This was done to conceal the retirement, but it offended the men that blindages which were built by their hands should preserve their enemies from the cold.

The desperate struggle on Visokaya had so thinned the garrison and weakened its numbers that it had lost the power of making a sufficiently strong defence of the remaining positions. Want of men and the absence of reserves was noticeable everywhere, and this, in the writer's opinion, was the chief cause of the failures which brought about the fall of the fortress.

It is very difficult to fix the exact number of the Russian losses in this fighting, because the troops which took part in it included, besides the whole of the Fifth Regiment, many combatant, non-combatant, and composite companies of other Arthur regiments and reserve battalions, hospital detachments, and

sailors. In all, more than eighty companies and detachments took part in the fighting on Visokaya and Flat hills, some of which had completely disappeared in the fighting, and others, hospital detachments and reserve battalions, were now drafted into other units, and of their losses it is very difficult to form an estimate. But the total loss in killed and those of the wounded who were taken to hospital certainly exceeded 5,000, and if the wounded who continued to perform duty are included, the total was probably nearer 7,000.

In the Fifth East Siberian Rifle Regiment alone, out of 23 officers, 26 ensigns, and 1,805 rank and file, in which number the non-combatant company is included, as it was present throughout the fighting on Flat Hill, the following casualties were sustained: 14 officers, 17 ensigns, and 1,251 rank and file, in which number the proportion of killed was about one in four.

If it is estimated that the Japanese in this fighting lost twice as many men as the Russians, *i. e.*, 10,000, and that their army had previously numbered 100,000 men, which was about five times the strength of the Russian troops employed on the positions at that period, it will be seen that after this fighting they remained six times $\left(\frac{i.\ e.,\ 100-10}{20-5}\right)$ as strong.

And so the desperate struggle on Visokaya Hill and its fall influenced very strongly the fate of the fortress, and were, so to speak, the turning point in the direction of the failures which led to its fall. Well may Kondratenko have said when he saw no means of preserving Visokaya Hill, "This begins the death agony of Port Arthur."

In conclusion, the author describes how at the end of the war he obtained three days' leave from the prisoners' camp at Sizooko and paid a visit to Tokyo. He and his companions did a great deal of sight-seeing, and visited among other things the museum, which already contained a large collection of Russian arms and equipment; but their interest was aroused at a fairly late hour on the last day of their visit by hearing that in a certain garden a feast of chrysanthemums was being celebrated by means of pictures, made almost entirely of live flowers and foliage. Hastening to the spot, they found that the garden was divided into four parts, in each of which were exhibited two large and two to three small pictures, illustrating popular scenes of Japanese legends and history. The majority of these naturally had reference to their recent war, and the place of honor was given to a large representation of the final struggle for 203-Meter Hill.

A large crowd was gathered round this picture, and, with the help of an interpreter, the writer was able to understand that among the Japanese the fighting on Visokaya was admired beyond any other incident in the war. Nowhere did they meet with such resistance, nowhere were the methods of fighting so ghastly, and nowhere did the Russians show themselves so courageous, resolute, and persevering, as on this occasion.

When the Japanese decided to erect at Port Arthur a monument to the fallen Russian soldiers, in honor of the gallant deeds of the garrison, and sought to place it on the spot which was most glorious to the defence, they decided upon Visokaya Hill. Surely this fact is more eloquent than words.

And yet this is far from being the way in which the Russians look upon the gallant actions of their own troops. In a slough of intrigue, and stirring up

all possible dirt, they apply a magnifying glass to the microscopic blots in the grandest struggle of the war, and while unspairingly baiting the seniors of the garrison over small trifles—very often invented and always exaggerated—they leave themselves no time to notice and reward the gallant deeds of those who took an actual part in the defence.

In conclusion, as the name of Tretyakov is so inseparably associated with that of Visokaya Hill, the author adds the following short note on his previous career:

General Tretyakov, at that time a young Sapper officer, earned considerable distinction during the Siege of Plevna. During the China War, at Hunmir, a small Russian force, consisting of two companies, Fifth Regiment, and a company of Sappers, was attacked unexpectedly by large masses of Boxers, but was saved by the courage and resourcefulness of Colonel Tretyakov, who threw himself forward, leading on his men, who were paralyzed from surprise, and finally dispersed the Boxers. Finally, at the Battle of Kinchow, he and his regiment greatly distinguished themselves, and sustained the attack of three Japanese divisions.

F. E. G. Skey.

THE WORK OF THE CORPS OF ENGINEERS OHIO NATIONAL GUARD*

AT CAMP OF INSTRUCTION, FORT BENJAMIN HARRISON, IND., SEPT. 1ST TO 10TH, 1910

HEADQUARTERS CORPS OF ENGINEERS,
OHIO NATIONAL GUARD,
Cleveland, Ohio, October 25, 1910.

THE ADJUTANT GENERAL OF OHIO,
COLUMBUS, OHIO.

SIR: I have the honor to submit the following report on the tour of duty performed by the Corps of Engineers of the Ohio National Guard at the Camp of Instruction, Fort Benjamin Harrison, Indiana, from September 1st to September 10th, 1910, inclusive.

* * * * * * *

For the benefit of engineer troops of the organized militia, a progressive course of instruction and exercises in military field engineering had been prepared by Maj. Thomas H. Rees, Corps of Engineers, U. S. A., Chief Engineer Officer, Department of the Lakes.

To assist in carrying out this course and to provide a competent corps of instructors, Company I of the Third Battalion of United States Engineers, under command of Capt. W. G. Caples, Corps of Engineers, U. S. A., had been ordered from Fort Leavenworth, Kansas, to Fort Benjamin Harrison. This company, which is maintained at the war strength of 151 men, had been at Fort Harrison a week before the arrival of the Ohio Engineers, and had established for itself the most complete and sanitary camp I have ever seen. The Ohio battalion was located alongside of this company, and was particularly fortunate in having the benefit of this splendid object lesson.

Captain Caples was detailed as Chief Engineer Officer of the camp and also as Instructor of Militia Engineer Troops. The two commands worked together constantly during the encampment, and mingled together socially when not on duty.

* * * * * * *

The course of instruction began Friday, September 2d. A detail consisting of Captain Troyan, Lieutenant Bradshaw, and sixteen men was assigned to reconnaissance work. A number of the

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* From the report of Maj. J. R. McQuigg.

Fig. 1. Capt. W. G. Caples, United States Engineers, and Maj. J. R. McQuigg, Ohio Engineers, on the Parapet of the Completed Field Work.

best sketchers of Company I, United States Engineers, were assigned as instructors. This detail devoted practically all the time during the encampment to sketching and map work.

The battalion was formed at 7.30 a. m., and marched to the northwestern corner of the reservation in the vicinity of Fall Creek, where, under the supervision of Captain Caples, Lieutenant Thomas, and details from Company I, United States Engineers, work was begun making gabions, fascines, and hurdles to be used as revetting material for the field work later to be constructed. Each company was required to cut and assemble the material for and construct two gabions, seven fascines, and ten hurdles. Permission to cut the necessary material had been secured from Brigadier-General Hodges, commanding Camp of Instruction, and the work proceeded without delay. A section of woodland, within which the material was to be secured, was assigned to each company. Details were made to cut the material, other details to carry it to a designated place, where still other details proceeded with the construction of gabions, fascines, and hurdles. At mess time the four-mule escort wagons provided by Company I, United States Engineers, were loaded with the completed material; the battalion re-formed and, followed by the wagon train, marched back to camp, where the material was unloaded. This work occupied all of Friday and the forenoon of Saturday, when a sufficient amount of revetting material had been provided.

Saturday p. m. was given to the construction of a standing trench. The battalion, together with a detail from Company I, was marched to a slight elevation just northwest of the camp site, where the trace of the work was laid out. The trench was to be 2 feet wide, 3 feet deep, and 120 feet long. The main arm of the work was to be 90 feet long, and was to command the ground to the north. The short arm was to be 30 feet long and form an angle of 120 degrees with the longer arm, and command the ground to the northwest.

The tool wagons were brought up, tools issued, each company divided into two reliefs, and the work begun. All sod was removed for a space of 9 feet in front of the trench, and preserved to conceal the excavated earth. The work was to have a command of 1.5 feet, and the exterior slope of the parapet was to be 1 on 6. There was to be a berm, or elbow rest, 8 inches wide along the whole front of the trench. When the excavation was finished, the parapet was completely covered with the sod which had previously been removed, and was then practically invisible at a distance of 150 yards in front.

While the trench was being dug a detail from each company was constructing a belt of high wire entanglement about 200 yards in length by 12 feet in width around both arms of the work and about 50 yards in front of the same. This entanglement was constructed of barbed wire, and consisted of one main course of four wires, very similar to a wire fence, on each side of which were constructed aprons at an angle of 45 degrees, each one of which carried four

Fig. 2. Rowing the Pontons into Position

additional wires, thus making a sort of triangular wire prism consisting of 12 wires. This obstacle was used to form the inner fence of a three-row high wire entanglement. The other two rows were built in the usual manner for high wire entanglement, the whole making a most effective obstacle that is practically impassable without the cutting of the wires.

* * * * * * *

The afternoon was devoted to instruction and practice in knots and lashings. The battalion was formed and a detail from Company I, United States Engineers, was assigned to each company as instructors. The companies were then divided into squads and the instruction proceeded, the men doing the work under the supervision of Lieutenant Thomas, United States Engineers, and the officers of the Ohio Battalion. Derricks, gins, and shears were constructed, and their various uses explained and illustrated. A battalion parade was held at sunset.

On Tuesday morning the battalion was formed and marched to the trench previously constructed. The problem was to convert the standing trench into a modern splinter-proof trench. All the necessary material had been previously collected. Tools were issued from the tool wagons, the companies divided into reliefs, a detail from Company I, United States Engineers assigned to each company, and the work proceeded under the supervision of Captain Caples, United States Engineers, and the officers of the Ohio Battalion. The sod was first removed from the parapet of the standing trench, and from a space of 9 feet further to the front. The trench was then widened to 5 feet, the section represented by the 3 feet additional width being also 9 inches deeper than the standing trench. While the digging was being done, carpenter details were making the frames for the splinter proof. As fast as the excavating was completed to the bottom of the original standing trench, the hurdles previously made were put into place as revetment on the forward face of the trench. The splinter proof frames were then put in position and covered with 1 inch plank, on top of which the earth was piled to the depth of 18 inches. A row of sand bags was placed along the inner edge and about 10 inches below the crest, constituting a sort of berm designed as an elbow rest, similar to that of the Japanese trenches. As fast as the digging was completed the hurdle revetment was put in place along the rear face of the trench and capped with a row of sand bags. In the bottom of the trench was placed a course of fascine revetment to prevent the crumbling of the 9-inch step or banquette tread on which the men stood to fire.

Although the amount of earth taken out of the converted trench was 50 per cent greater than that taken from the standing trench, yet the command of the work was not raised, the excess earth being used in widening the parapet to 18 feet.

At the 120 degree angle between the long and short arms of the work a traverse was constructed of 6 gabions filled with earth. On

Fig. 3. The Completed Bridge and the Men Who Built It

the left of the work a number of loopholes were placed in the parapet. The parapet was then levelled off to a slope of 1 on 12 and the sod replaced. When this was done it was impossible to distinguish the parapet or locate the trench at a distance of 200 yards in front of the work. A drain cut to the bottom of the trench was constructed from the left arm of the trench to the lowland just to the left of the work, and a shallow surface drain in the rear of the entire length of the inner face of the trench. While the splinter proof was being constructed other details were placing a belt of Raymond wire entanglement 16 feet wide in the grass and weeds on the low ground about 50 yards in front of the high wire entanglement previously constructed.

The advance guard bridge train of the Third Battalion of United States Engineers had been sent from Fort Leavenworth, Kans., to Fort Harrison for the use of the Ohio Battalion. Wednesday p. m., September 7th, the battalion was formed, and with a small detail from Company I, and followed by the bridge train consisting of one complete division of the advance guard equipage, marched to Fall Creek in the northwestern corner of the reservation.

The problem was to construct a ponton bridge across Fall Creek, which, at the point selected, was 100 feet wide and about 5 feet deep, with considerable current. The bridge train was drawn up in order opposite the point selected for the bridge, the companies divided into details as prescribed in the ''Ponton Manual,'' and the command ''Construct the Bridge'' given. Under the supervision of Captain Caples and Lieutenant Thomas, United States Engineers, and the officers of the Ohio Battalion, the boats were constructed, launched, rowed into position, and the bridge 100 feet long completed in one hour. Considering the fact that, with three exceptions none of the enlisted men of the Ohio Battalion had ever before seen a ponton boat, and that the work was all new, the rapidity with which the bridge was constructed, and the manner in which the work progressed, was surprising. General Hodges and his personal staff witnessed the construction of the bridge. On its completion, the mounted section of Company I marched over it, followed by the Ohio Battalion. The bridge was then taken up in twenty minutes, the boats dismantled, and the wagons loaded. The battalion was then formed and, followed by the bridge train, was marched back to camp, where it arrived at 7 p. m.

* * * * * * *

The battalion was formed at 1 p. m., September 8th, and followed by the wagon train and pack train, marched to the northwest corner of the reservation in the vicinity of Fall Creek, where it proceeded with the demolition work. A battery of four land mines was prepared by making excavations 2 feet square and 3 feet deep about 30 feet apart. In the bottom of each one of these was placed 17 pounds of dynamite. Electric fuses were connected in such a way as to enable the charges to be exploded by electricity. The excavations were then filled in and thoroughly tamped. When all was in readiness, officers and men were ordered to places of safety,

Fig. 4. Bridge Constructed in Fifteen Minutes Over One Which Had Given Way Under Weight of Ponton Wagon

and the battery discharged. The effect was terrific. Great masses of earth were hurled for hundreds of feet into the air, and a crater 8 feet deep and 15 in circumference was made by each charge. It was easy to see what would be the result of exploding such mines under advancing columns of troops or charging cavalry.

The Chief of Engineers of the Army had approved the requisition of Captain Caples for funds for the purchase of certain material for demonstration purposes. A number of steel rails were loaned by the Big Four Railroad, and ties, together with necessary amount of fish plates, bolts, and spikes were purchased and transported by the wagon train to the place where they were to be used. After the land mine demonstration the battalion proceeded to construct 100 feet of railroad track. This construction was in all respects the same as the standard track. The ties were placed, the rails spiked and the fish plates bolted, exactly as is done in the construction of all well-built steam railroads. The section of track completed, the next problem was to destroy it by the use of high explosives. A half pound of rack-a-rock was placed in the web on one side of the rail, and a similar charge on the opposite side, about 2 feet from the first charge. Electric fuses were inserted in each charge and connected with the wire attached to the magneto blasting machine. The officers and men were ordered to a safe distance and the charge exploded. In each case a section from 2 to 3 feet long was cut out of the rail and the ease and certainty with which this was done was as gratifying as it was surprising.

The next problem was to cut bridge steel by explosives to illustrate how bridges can be destroyed. Steel I-beams and angle iron used in modern steel bridges had been provided. Charges of from 2 to 3 pounds of rack-a-rock were used, depending on the size of the beams.

While the railroad was being constructed and demonstrations in the use of explosives were being made, a detail from Company I was preparing a fougasse. Near the bottom of the excavation were placed 50 pounds of dynamite, in front of which was laid a large quantity of stones and rocks. Officers and men were ordered to places of safety and the charge exploded. The result was such as to inspire terror in any body of troops making an attack. Stones and rocks were hurled from 200 to 400 yards to the front and the crater made by the explosion was 10 feet deep and 20 feet in diameter.

It was getting dark when the fougasse was exploded and the battalion was formed and marched back to camp, after a most vigorous half day, every minute of which was exciting and instructive.

* * * * * * *

The tour of duty was by far the most instructive in the history of the organization. Thanks to Gen. C. L. Hodges, Commanding Camp of Instruction, practically the whole time was given to engi-

Fig. 5. Discharging a Battery of Land Mines

neering work. The battalion was kept intact all the time, and was not cut to pieces by details as in years past at our State camps.

Engineer troops, in addition to being prepared to fight as infantry, have a definite technical service to perform. In this respect they are unique—being the only special troops that are also fighting troops and therefore troops of the line. The fact that they are line troops, however, does not make them any the less special troops. In order to prepare for their special service they must be given the same immunity from details of officers, men, animals, and material that is given to all other special troops, such as the Signal Corps, Hospital Corps, and the Ordnance.

I am informed by officers of the Corps of Engineers of the regular service that the same is equally true of their training. This matter seems to have been thoroughly appreciated by General Hodges, and at this encampment the engineer troops enjoyed complete immunity from detail for the first time, and for the first time really satisfactory results were obtained in the special training of engineer troops.

It is to be hoped that this immunity from detail will be speedily granted by War Department orders, for until this is done it will be extremely difficult, if not impossible, to bring engineer troops to a proper standard of efficiency in their special work.

The thanks of the organization are due to the Chief of Engineers of the Army for promptly approving the requisition of Captain Caples for funds to purchase the material necessary to carry out the course of instruction, also to the Adjutant General, Col. Wm. A. Simpson; to the Chief Quartermaster, Lieut. Col. Thomas Cruse, and to the Chief Commissary, Capt. Jack Hayes, for numerous courtesies extended in connection with their respective departments.

But the one thing that contributed most largely to the success of the encampment was the presence of Company I, Third Battalion, United States Engineers. The officers and men of this splendid organization did everything in their power to give the Ohio battalion the most possible instruction in the limited time. Officers and men worked without regard to hours, and several times it was pitch dark when the two commands returned to camp after a day's instruction and practice. The good feeling, social intercourse, and esprit de corps of the two commands were matters of comment throughout the camp of instruction.

Very respectfully,

J. R. McQuigg,
Major, Corps of Engineers,
Ohio National Guard.

Joseph Gilbert Totten

Joseph Gilbert Totten was born at New Haven, Conn., August 23, 1788. He entered the United States Military Academy November 4, 1802, and was graduated and commissioned Second Lieutenant in the Corps of Engineers July 1, 1805. He almost immediately joined his uncle, Jared Mansfield, Surveyor General of Ohio, as assistant on survey work in the then West and resigned his commission in the Army March 31, 1806.

On February 23, 1808, he was reappointed to his former rank and served until 1812 as assistant to Col. Jonathan Williams in the construction of Fort Clinton and Castle William, New York Harbor.

He was promoted First Lieutenant July 23, 1810, and Captain July 31, 1812. In the War of 1812 he served as Chief Engineer under General Van Rennselaer and took an active part in the Battle of Queenstown. He also served in the same capacity under General Dearborn in 1813, and under Generals Izard and Macomb in 1814.

He was brevetted Major, June 6, 1813, for ''meritorious services,'' and Lieutenant-Colonel, September 11, 1814, ''for gallant conduct in the Battle of Plattsburg.''

In 1816, he was appointed member of the board of engineers to examine the coast and prepare plans for the necessary defensive works. In 1817, he was placed in direct charge of the fortifications at Rouses Point, New York. He was promoted to Major November 12, 1818, and in 1819 was again placed on the above-mentioned board, which now consisted of General Barnard and himself.

He was engaged for several years in the preparation of the projects for the defense of the coast harbors, and these reports were on such broad lines that even to-day they form an excellent study, notwithstanding the great changes in arms and armaments. He was promoted Lieutenant-Colonel May 24, 1828, and from 1825 to December, 1838, he was in charge of the construction of Fort Adams, R. I. Fort Adams is one of the best types of the forts of that period and still stands as a monument to General Totten.

He was appointed Colonel and Chief Engineer of the Army December 7, 1838, and continued to serve in that capacity until his death, April 22, 1864. He was promoted Brigadier-General and Chief Engineer, United States Army, on March 3, 1863.

In the invasion of Mexico, Colonel Totten assumed direct charge of the engineering operations of the Army under General Scott and directed the siege of Vera Cruz. He received the brevet of Brigadier-General ''for gallant and meritorious conduct at the siege of Vera Cruz.'' He is probably most widely known as the designer of the Totten embrasure for the old style forts, although his work on Hydraulic and Common Mortars was also well known at the time (1838).

Colonel Totten was ex-officio Inspector of the Military Academy from 1838 till 1864. He was member of the Light-House Board from 1852 to 1864, one of the original regents of the Smithsonian Institution, an incorporator of the National Academy of Sciences, a harbor commissioner of New York and Boston, and a member of many scientific associations.

The degree of A. M. was conferred upon him by Brown University, Rhode Island.

He died April 22, 1864, at Washington, D. C. The day before his death he was brevetted Major-General, United States Army, ''for long, faithful, and eminent services.''

AN A-FRAME MOVABLE TOP TO PROVIDE INCREASED DEPTHS ABOVE FIXED DAMS

BY

Lieut. LEWIS M. ADAMS
Corps of Engineers

In those rivers which are adapted to improvement by means of locks and fixed dams, careful consideration should be given to the possibility of securing the proper navigable depth by installing movable tops on the dams. The principle of the movable top is peculiarly pertinent when the stream under consideration is one which has a very small low-water discharge. On such a river, the navigable pools practically become horizontal surfaces during the periods of minimum discharge and the gages below the dams frequently show so little depth on the lower lock gate sills that navigation at normal loading ceases. If it were possible to raise the crest of the dam a few feet when the river fell to near the low-water stage, the whole horizontal pool surface would be correspondingly raised and navigation could proceed under normal conditions as to loading.

This is one of the advantages to be secured by a movable top to a fixed dam. Another advantage consists in being able to float off grounded vessels by temporarily dropping part of the movable top of the dam above, and thereby raising the river surface. The movable top presents several other important advantages, among which may be cited: Less guard above normal pool necessary for lock walls; the fall over the front of the dam is reduced, and for dams founded on piling, or crib-built, this is quite important. Flood heights will be materially reduced for a given discharge.

Before proceeding further, it should be stated that credit for originating the A-frame type of movable dam belongs to Mr. B. F. Thomas, United States Assistant Engineer, now in the Cincinnati office. A discussion of this dam appeared in the Journal of Engineering Societies, June, 1896.

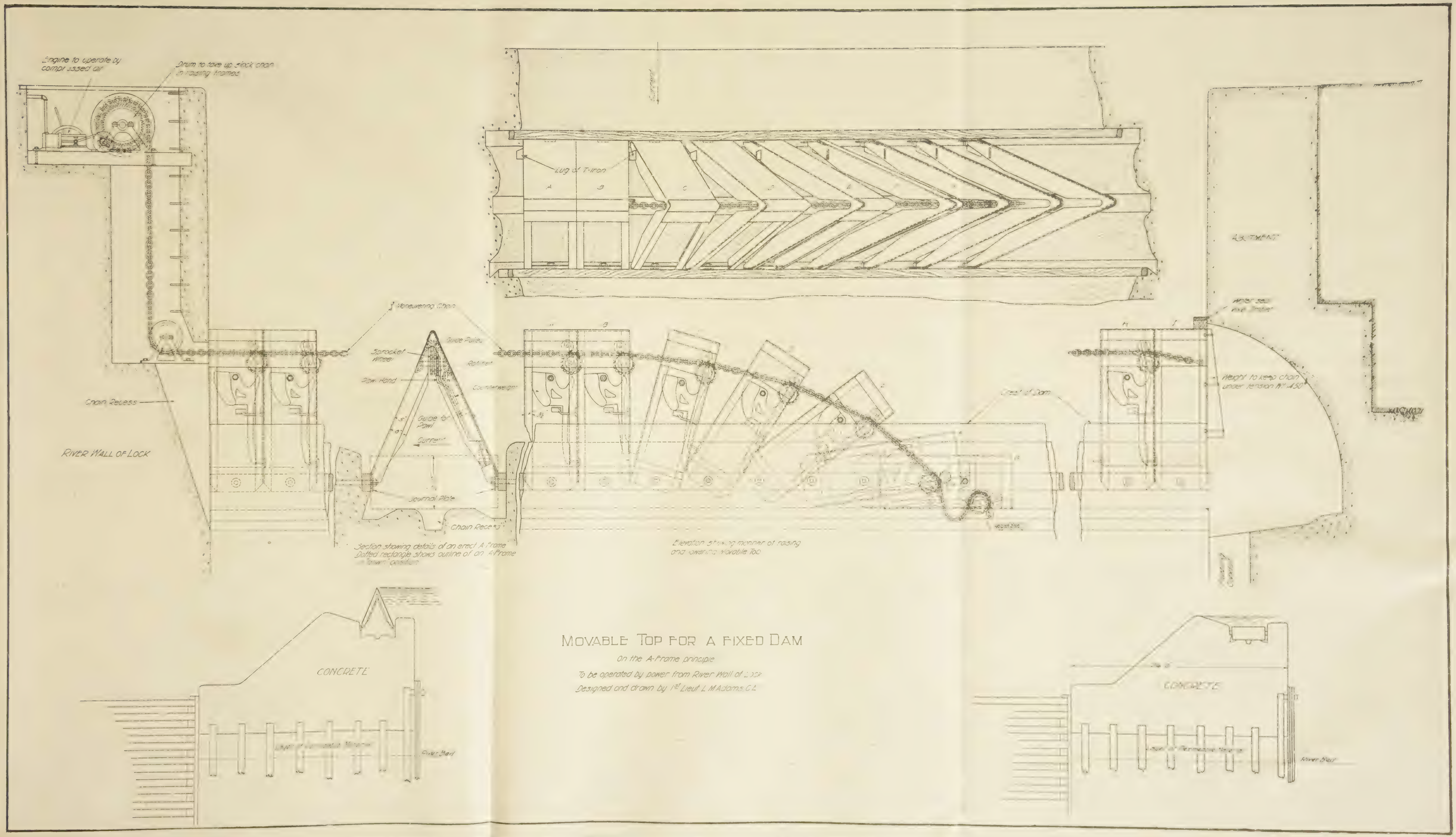
A movable top, substantially the same in design and operation as that shown in the illustration accompanying this article, was

submitted by the writer as one of a number of tentative schemes for a movable top for new Dam No. 5, Monongahela River, located at Brownsville, Pa. Theoretically, the design was almost ideal for the situation, but it was novel, expensive, and somewhat liable to be obstructed by drift during the operation of raising and lowering. Two hundred and seventy-seven frames of the type shown would have been required for Dam No. 5, on the Monongahela, and with their mechanical parts difficulty in operation was feared and the design was abandoned for one on the hinged-flashboard principle. The following conditions on the Monongahela River make the use of an A-frame movable top like the one to be described quite possible:

The fixed dam is a fairly high concrete structure with vertical back, which tends to prevent any gravel or sunken drift from getting over the crest or into the A-frames. The crest of the dam is modified to suit the A-frame top, so that when in the "down" position the projecting T-iron lugs on the frames will always have more than 1 foot of running water passing over them; this should allow all floating drift to go over the dam. When the river is at so low a discharge as to require the movable top to be raised, there is no current and no drift to contend with. Even if in raising the top it should be obstructed by drift, it would occur at so low a river stage that men could walk out on the crest of the dam and remove it. Obstruction in lowering for a rise would be somewhat more serious.

The frames and parts thereof could very well be made of pure "ingot iron" to reduce rust, corrosion, or possible electrolytic action.

Inspection of the illustration will show an A-frame to consist essentially of two 3½ by 8 by ½ inch angles and two 3½ by 5 by ⅜ inch angles. Each pair of angles is arranged as an inverted V and carries a skin of ⅜-inch plate on the upstream panel which they form; this skin is carried over the top of the frame and down the other (downstream) side a sufficient distance to cover the moving parts in the apex of the frame. These mechanical parts consist of a sprocket with lugs to fit a ¾-inch open-link chain; and on the same shafting, and keyed thereto and to the sprocket, is a ratchet. Above the sprocket is mounted a small iron guide pulley, which prevents the chain from twisting or jumping out of the sprocket grooves. The next important element is the large hatchet-shaped pawl, pivoted against the under surface of the upstream



MOVABLE TOP FOR A FIXED DAM

On the A-Frame principle

To be operated by power from River Wall of Lock

Designed and drawn by 1st Lieut L. M. Adams, C.E.

skin, where it is least liable to obstruction or injury. Each pawl is provided with a counterweight, which gives it a tendency to rotate in a counter-clockwise direction about its pivot. This tendency to rotate keeps the pawl-hand engaged in the ratchet and binds the operating chain. To disengage the pawl-hand at the proper moment, a lug of T-iron is riveted to each frame near the bottom of the 3½ by 8 inch angle legs. These lugs show up plainly in the "plan." Each pawl is provided with a guide for the long arm, which is actuated by the T-iron lug.

The operating chain passes through the sprocket and under the guide pulley of each A-frame and is carried out of the frame next to river lock wall around a fixed snatch-pulley, thence up a large well in the wall to a chain drum. The drum, operated by a small reversing engine, has capacity sufficient to take up all the slack chain when the dam is raised. When all the frames are up, the chain is held taut across through the dam by the 1,450-pound counterweight, which is bolted to the last frame next to the abutment, shown to the right in the illustration. This feature is provided to start the operation of lowering. The engine unwinds the chain drum and immediately the last, or abutment, counterweight frame "I" begins to drop to the right (illustration) into the recess in the abutment. When it gets to the position corresponding to that of frame "C" in illustration, the lug at its foot draws away from and releases the pawl-arm of frame "H." This action engages the pawl-hand of frame "H" in the ratchet and locks the operating chain in the sprocket of frame "H." Frame "H" is now carried to the right by the superior moment exerted by frame "I." In precisely the same way, all the frames drop to the right to the lying position, and the slackened operating chain drops out of the way into the recess provided for it in the river wall of the lock.

To raise the top, the reverse operation is employed. The first frame to come up will be the one next to the river wall, which is started from the "down" position with operating chain still locked in the sprocket as it was on being lowered. As soon as this frame reaches the position corresponding about to that of frame "E," it picks up the next frame out from the wall, and so on. Just before it reaches the position corresponding to that of frame "B," it becomes over-balanced, due to the heavy 3½ by 8 inch angles and the pawl counterweight, and it tends to rotate in a counter-clockwise direction. This causes it to complete its last movement to the "up"

position by force of gravity without mechanical effort, the pawl-hand already having been released from the ratchet by the action of the T-iron lug of the following frame. The larger, 3½ by 8 inch, angles also form a comparatively smooth iron floor when the dam is in the "down" position. Deep floating ice and logs will pass entirely over the frames when down, the concrete edge below the frames being 4 inches lower than that on the upstream side.

The journal plates at the frame hinges bear against iron washers, which give the proper spacing to the 4 by 8 inch wooden stringers. The downstream stringer, which takes up part of the heavy compression, is borne by a solid concrete corbel. One man at the maneuvering engine should raise or lower the entire movable top in five minutes. As the usual maneuvering boat would not be necessary with this type of dam, the cost of such a boat should be taken into consideration in deciding between such projects. The cost of the top shown herewith, erected complete, would approximate $15,000; this estimate being for a dam with spillway about 554 feet long.

DISCUSSION

Maj. J. C. OAKES

Corps of Engineers

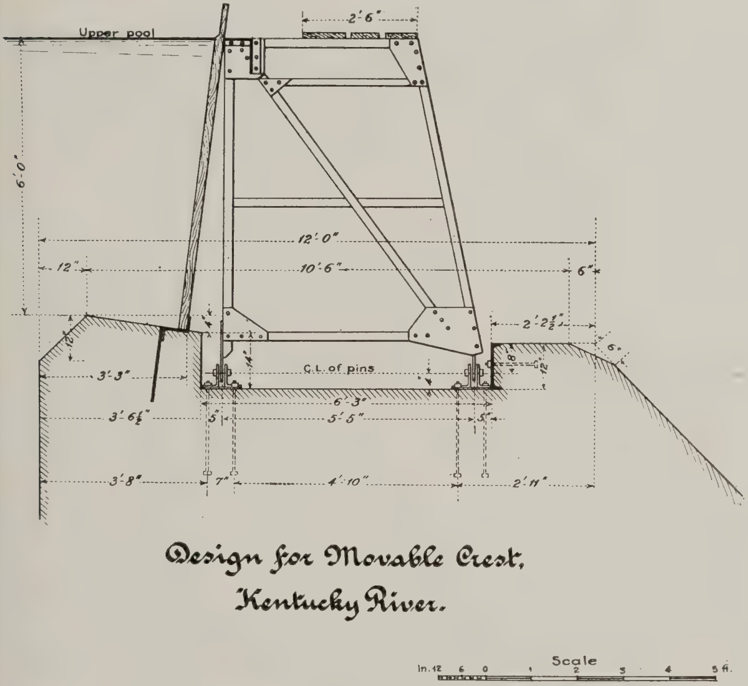
In mentioning the advantages of the use of movable crests on permanent dams the author has omitted to mention one of the most important, viz: that the use of such crests permits the dams to be placed at greater distances apart by increasing the low-water lift while reducing the flood heights by something less than the amount of the height of the crest. In this manner, the number of dams and the cost of canalization of a river is much reduced. This is particularly important when the flood height must be kept within a certain limit, on account of possible damage to property along the river banks. It is for this reason that movable crests have been placed on several of the dams on the Kentucky River and on No. 11, Muskingum River.

There are, in my opinion, two principal objections to the design under consideration: *first*, the use of the chain for raising and lowering the frames and, *second*, a more important and inherent fault is the necessity of the successive frames "nesting" or falling one within the other.

As to the use of chains, it must be noted that the velocity of flow over a dam with movable crest down will be much greater than the ordinary velocity of flow of the stream and that there will be surges and suction which will keep the chain in constant motion with re-

sulting wear and rapid destruction. This wear would take place more rapidly where the chain enters the lock wall; but, in my opinion, it would take place throughout its length, notwithstanding the recess in the concrete provided for it.

On the Kentucky River, Dams Nos. 11 and 12 have movable crests, increasing the lift by 6 feet. Dam No. 13, now under construction, and Dam No. 14, about to be put under contract, will also have similar crests. These crests are of the Poirée or needle type. Dam No. 11, on the Muskingum River, has also a movable crest, but it is of the Boulé type. On the Big Sandy River there are five movable dams, with Poirée needles for the pass and Chanoine wickets for the weirs. Chains were at first used on these dams. On the Big Sandy River no trouble has resulted, but on the dams with movable crests the chains were worn out in one season and their use has been abandoned. On the Kentucky, No. 11 Dam, the connecting rods used to fasten the successive trestles together when upright, were at first hinged to the trestles at one end. The surging of the overflow when the crest was down caused these rods to move up and down so that many were caught by drift and badly bent, making it necessary to detach the rods from the trestles.



Design for Movable Crest,
Kentucky River.

Fig. 1.

The reason that no trouble is ordinarily had with chains when

used in movable dams is that, except for a few minutes after the dams are lowered, there is little increased velocity and no surging, so that the chains lie quietly on the bottom and are therefore not subject to undue wear.

Another objection to the use of the chain is that in lowering the crest, at any instant at least four of the frames are in inclined positions with openings between them through which the water will rush, carrying any drift that may be passing. If a snag should be caught between any two frames, the remainder of the dam could not be lowered, with the probable result that the movable crest would be lost.

In my opinion, the A-frame type for use either as a movable crest or movable dam would be very much more valuable without the chain, in which case each frame could be lowered separately and there would be less danger of catching drift. In any case, the use of the chain in connection with the movable crest is, in my opinion, not practicable, on account of the certainty of its destruction during submergence.

The second objection to the A-frame is that if one frame should be bent sufficiently to interfere with its falling inside of the one next to it, or if the same result should occur from the lodgment of a rock or piece of drift, the remainder of the dam could not be lowered and the crest would probably be lost. While without the chain and on top of a permanent dam there is not so much chance of this trouble occurring, still it is a possibility and one to be avoided.

These conclusions are the result of experience in the Second Cincinnati Engineer District with movable dams and movable crests on fixed dams.

The first movable dams constructed in this district were on the Big Sandy River. The trestles supporting the needles were 4 feet apart, and they were lowered by chains in the same manner as proposed for the A-frame under discussion. As soon as a portion of a dam is lowered the water rushes through the gap, drawing the drift with it. On one occasion the drift fouled the first trestle of Dam No. 3 when an attempt was made to lower it, and, inasmuch as these trestles were close together and were to lie one inside of the other in a horizontal position when down, the first trestle being prevented from lying down, prevented the lowering of all the others, with the result that the dam was caught and was destroyed. Due to this experience, it was determined to place the trestles sufficiently far apart so that each one could be lowered independently of the others; this was done and no further trouble has ever been had on account of drift while lowering the dams. On these dams chains are used to raise the trestles successively. No particular wear of the chains thus used has resulted, but it must be noted that the velocity of the current flowing over the movable dams, after they are lowered, only exceeds the natural velocity a very short period of time, after which the dams offer little more

obstruction than ordinary bars in the river and there is no unusual current to move the chains.

The trestles of the movable crests on both the Kentucky and Muskingum rivers are so spaced that each can be lowered irrespective of the adjacent ones, so that even if one should be prevented from falling into place the others may be lowered and the dam saved. Tracings are forwarded showing the designs of the movable crests on these rivers.

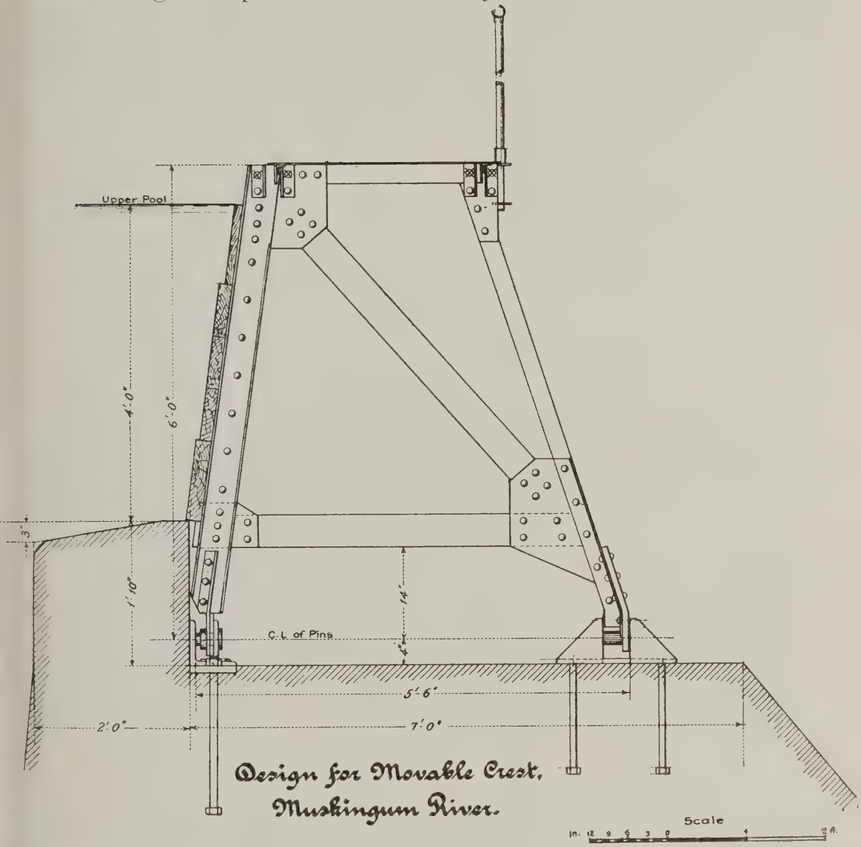


Fig. 2.

In lowering these dams one panel is completely removed at a time, and the trestle lowered so that only one trestle is in danger of being fouled at one time.

A consideration of this whole subject leads me to the conclusion that the primary considerations for a successful design for a movable crest are as follows: that each element shall be independent of each other element; that when a panel is removed there shall be no trestle or frame standing to catch the drift; that there shall

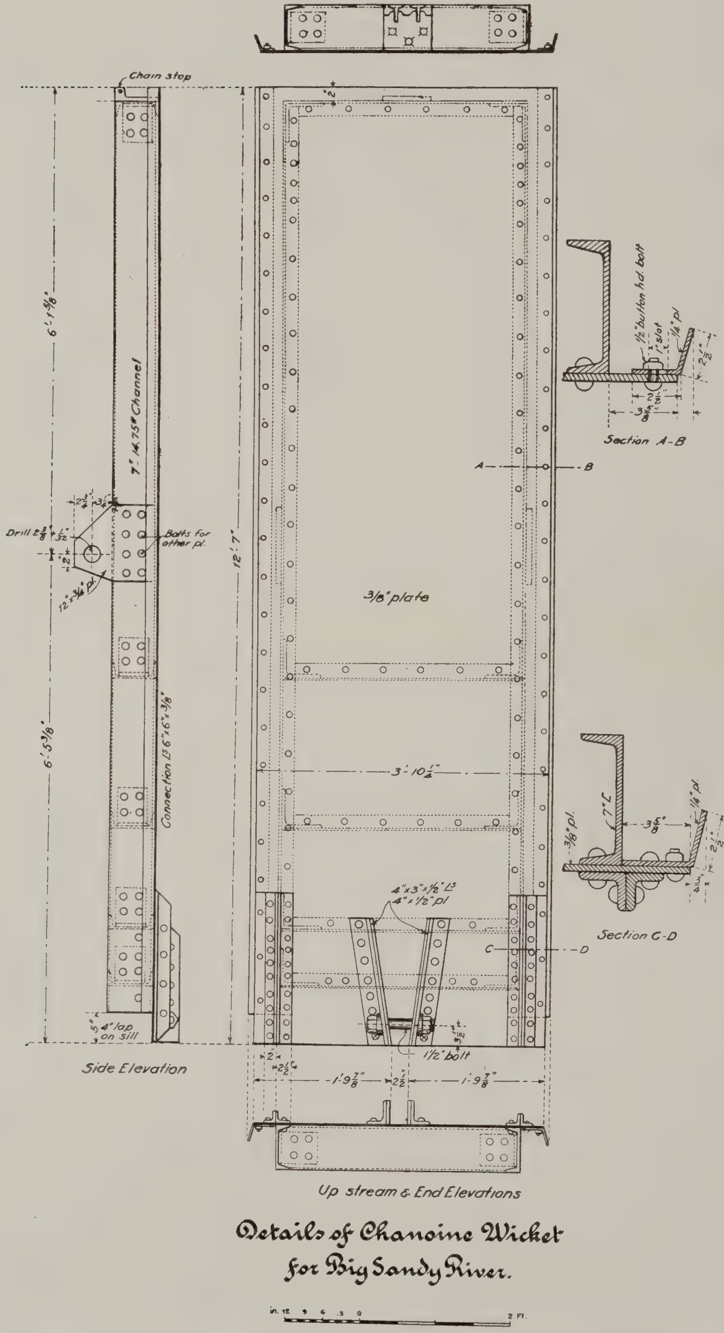

Chain stop
6'-1 5/8"
7" 14.75# Channel
2 3/4"
3 1/4"
Drill 2 3/8" + 1/32"
2"
Bolts for other pl.
12"×3/4" pl.
12'-7"
6'-5 3/8"
Connection ⊾s 6"×6"×3/8"
5"
4" lap on sill
Side Elevation
2"
3/8" plate
3'-10 1/4"
A
B
1/2" button hd. bolt
1" slot
1/4" pl.
2 1/2"
2 1/2"
3 5/8"
Section A-B
4"×3"×1/2" ⊾s
4"×1/2" pl.
C
D
1/2" bolt
3 1/2"
3/8" pl.
7" ⊏
3 5/8"
1/4" pl.
2 1/2"
4"
Section C-D
2"
2 1/2"
1'-9 7/8"
2 1/2"
1'-9 7/8"
Up stream & End Elevations
Details of Chanoine Wicket
for Big Sandy River.
in. 12 9 6 3 0
2 Ft.

Fig. 3.

be no loose parts exposed to the surging action of the current when the crest is down; that it may be lowered rapidly from the lock wall and abutment; that a portion of the crest may be lowered for regulation purposes without its being necessary to lower the whole crest; that it may be lowered even if overflowed; that it may be easily raised, and that it shall not obstruct drift when down. It seems to me that the Chanoine wicket and the Thenard shutter, or modification of these types, comply with the requirements to greater extent than any other types. The principal objection is, of course, that they are difficult to raise, but by the use of a boat, with power, no extraordinary difficulty should be encountered.

The Thenard shutter would require slightly less width of top of the permanent dam and, except that it would require more power to raise than the Chanoine wicket, it seems to me to be preferable for heights of 6 or 7 feet. I do not think there would be difficulty in raising shutters of 3 to 4 feet in width, except possibly the last few, which could be made smaller, say, 18 inches, or, even, 12 inches wide toward the end of the crest. With a maneuvering boat each individual shutter could be raised separately and could be lowered separately, or an arrangement could be made to lower a number of the shutters at the same instant by means of tripping bars. For heights of crest under consideration, the Thenard shutter would not require greater width of top of dam than would the Poirée, Boulé, or A-frame types, because the shutters could be so hinged as to require no sills for protection, while in the case of the other

Fig. 4. Weir of Dam No. 1, Big Sandy River

types mentioned the crest, when down, must be protected by sills.

Some will object to the Chanoine and Thenard types on the ground that they are not ordinarily tight, but it is possible to make them so. On the Big Sandy River a type of wicket is used that provides a dam that is practically water-tight. A copy of the plan is forwarded herewith with a photograph showing one of these weirs holding the water behind it with practically no leakage. The peculiarity of the design of the wicket is a steel-plate lip at the end of the wicket which bears on the sill, and on each side of the wicket an angle iron, the projecting leg making an obtuse angle with the front face of the wicket. The wickets are of steel, which gives them unusual stiffness, and these angles are planned to give only a play of about ¼ to ½ inch between wickets. In this V-shaped space there are placed strips of wood, which are held in position by pressure of the water and, when the dam is lowered, these strips are wasted, being practically of no value. In the Thenard type the shutters would need still less play and the side angles could be so planned as to leave practically no space between them when the crest should be raised, thus making practically a water-tight dam.

Mr. B. F. Thomas

Principal Assistant Engineer
Cincinnati, Ohio

The movable dam, as at present built and operated, is by no means to be classed as an ideal form of river improvement. The same may be said as to stationary or fixed dams.

In this country the Great Kanawha and Ohio rivers have a number of movable dams of the Chanoine wicket type, and the Big Sandy River has several of the Poirée needle type with Chanoine weirs. There is one objection in common to all of these dams, and, in fact, to all the movable dams of the world, and that is that they can not be safely left standing when there is ice, or when there is probability of an overflow of a few feet. This defect renders movable dams wholly useless during all the winter months, and sometimes far into the spring, or early summer, during which time navigation, and the various industries dependent upon it for supplies, fuel, etc., and for shipping their output, are subjected to delays and annoyances always incident to open river conditions on rivers of medium depth. In compensation for this disadvantage such navigation as can be maintained is not delayed by having to pass through the lock at each dam, and this may become a considerable item where large tows are formed, as with coal on the Upper Ohio River.

STATIONARY DAMS

Where stationary dams are employed, navigation goes on uninterruptedly throughout the year, except when the pools are frozen over, or at flood times, but the objection is always present that tows

must be broken up and everything must pass through the locks, and the further objection arises that such dams increase flood heights. To just what degree fixed dams affect extreme flood levels is an open question and one not capable of demonstration, but that such structures do increase the heights to which rivers will rise there seems little doubt, particularly the small rises known as "pop" rises or "flashes." In the natural state of the stream, these rises will raise the water level say 10 or 20 feet, without affecting the crops which are everywhere grown on the lowlands, near the river and its little tributaries. These lands are, by reason of the winter and spring overflows, always very rich, and are the best corn producers on every bottom farm. Now build a dam in the river 10 or 20 feet high, and the ordinary or low water level just above the dam is at once raised to what heretofore has been a medium flood level. What will now be the effect of a 10-foot or 20-foot flood? Unless the capacity of the stream for discharging flood-water has been increased, will not the river immediately above the dam be raised to a level full 10 or 20 feet higher than the crest of the dam, and must not the farmer move back off his productive lowlands to a contour 10 or 20 feet higher than before? Of course, the area of a waterway, except in canyons, is greater at a 10 or 20-foot level than it is at low-water level, and to this extent the discharge area is affected, and greater precipitation and run-off would be required to produce a 10 or 20-foot rise than would be the case with the original low-water mark as the minimum stage.

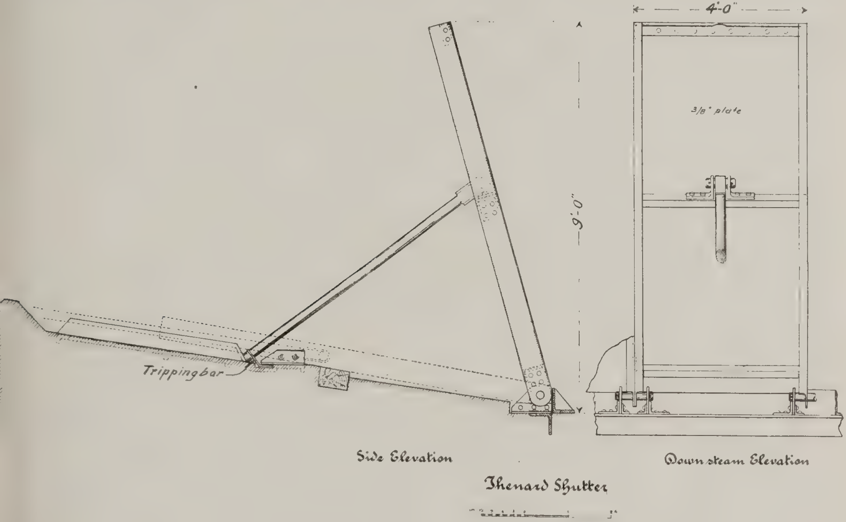


Fig. 1.

MOVABLE TOPS

In order to overcome, at least partially, the objections to movable

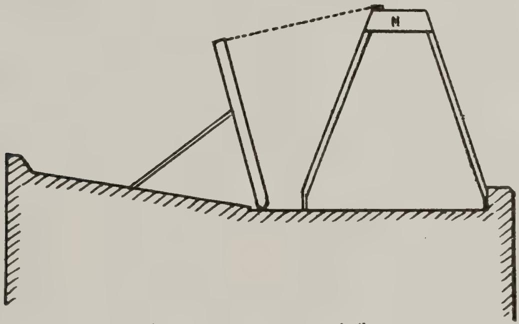
dams, and at the same time in a measure relieve one of the serious results attributed to fixed dams, it has been proposed to combine the two systems by placing the crest of a stationary dam several feet below proposed pool level and obtain the remainder of the depth required by means of a movable dam on top. This would, to a considerable extent, insure permanent depths at times when movable dams could not be maintained and at the same time reduce the overflow contour. One serious objection would remain, however, as all navigation must still use the locks for passing the dams, but this will become less objectionable as more dams are completed on a river. For instance, on the Ohio River, great coal fleets are held for months at head waters awaiting sufficient depths to float them to market, when all the towboats at command are rushed down the river. With permanent water this coal would go as fast as mined, from pool to pool, thus employing a few towboats constantly, except in times of ice, rather than many all at one time. The great capital invested in towboats and barges could then be reduced to the minimum necessary to move the output. Although movable tops of dams have been in use on the River Orb, in France, since the Eighteenth Century, and on many other rivers for years past, there has not been sufficient experience with them to test either their efficiency, practicability, or advisability.

The desirability of reducing the heights of fixed dams by the introduction of tops which will hold the pools at normal levels during dry seasons, and ordinary water stages, and yet be out of the way during flood times, has long been recognized by those whose studies and work have led them to give the matter attention, but the method by which this result might be brought about has as yet had no satisfactory solution. An example of the drum type of dam is in use on the Monongahela and another in the back channel, Davis Island, on the Ohio River. An automatic drop wicket is also used at one place on the Monongahela River. On the Muskingum River there is a movable top of the Boulé gate type, and on the Kentucky River the Poirée, or needle, dam has been introduced on top the later fixed dams. With the exception of flashboards these are the only movable tops now recalled in this country and the experience with these has so far been rather limited, and the results may still be regarded as somewhat in doubt. The Poirée dam is simple, economical, and not difficult to operate, but the trestles when down are subject to attack from drift and ice and for this reason, if for no other, the type is objectionable. Still there is no other type at present in use which offers more promise of success for lifts of 6 feet or more. For a lift of 6 feet this dam will cost about $10 per linear foot, or $1.67 for each foot of lift. The drop wicket above mentioned has a cost of $2.67 per foot head and the drum about $8.00 per foot head per linear foot. The cost of the Boulé is $3.33. It will be seen that the Poirée is much cheaper than the other forms and the renewal of a few trestles now and then can be afforded. While the Poirée seems to offer greater promise

of success than other types at present in use, the writer believes that either the Thenard shutter or the A-frame would be far preferable to anything so far tried.

TYPES OF TOP SUGGESTED

Thenard Shutter.—On taking charge of the River Isle in 1828, M. Thenard found a number of masonry dams which, while they caused serious inundation to lands at high water, yet failed to supply the navigable depths desired in dry times. To remedy both defects he reduced the crests 2.63 feet and placed thereon wooden shutters 1 meter high by 2 meters long, hinged at bottom and supported by a prop hinged above the middle of the shutter and resting at bottom against a projection on the masonry floor. The shutters were lowered (falling downstream) by means of a tripping bar engaging the props at bottom successively and moving them sidewise away from their supports. This bar was moved by suitable gearing placed in the lock masonry. But while the lowering was quite easy, the raising of even a small shutter against the current on top of a dam was difficult. To make this easy a row of counter-shutters was placed just upstream of the others, made so as to fall in the opposite direction. When down these were latched to the floor. When the latches were released the force of the current brought these shutters up and shut the flow off temporarily so that the dam tender could go out on the dam and raise the main shutter. As soon as the river rose over the counter-shutters and filled the space between them and the main shutters the pressure was taken off the former and they fell back to the floor, out of the way. Heads in excess of 10 feet are now sustained by dams of this character in India, a boat being used for raising. In recommending the trial of this type of dam, the writer would omit the objectionable counter-shutter and make the main shutters of such size as could be readily raised by a maneuver boat or cableway. Even a magnet may be used for raising steel



Thenard Shutter with "A" frame Service Bridge

Fig. 2.

shutters. For rivers carrying drift or ice, the writer sees no superior to the Thenard shutter, as it has nothing whatever exposed. With good tripping bars it can be lowered with great facility, even in running ice. Its cost should be little greater than that of the Poirée. As a movable dam for such heights as are now given the Chanoine wicket, the Thenard, in the opinion of the writer, is far superior to any now so employed.

A-Frame Dam.—The main criticism which has been made to the writer on this type of movable dam is that the continuous chain by which the frames or trestles are raised and lowered will have a tendency to become entangled with drift while the dam is being lowered. Such entanglement would, without doubt, cause much delay, and might result in a failure to get the dam down, as, with this form of dam, if one trestle or frame fails to go down, the whole remaining dam must stay up until the obstruction is removed. In order to overcome this difficulty suggestion has been made to have a separate chain for each frame, or to dispense with chains entirely. The time required for raising the dam will be increased considerably with the adoption of either of these suggestions, but as a rule there is no necessity for speed in raising. A dam without chains can be lowered quite as rapidly as with them by simply pulling or pushing the frames ''out of plumb'' when they will fall of their accord.

Kanawha and Big Sandy Dams with Service Bridges.—There are eight movable dams on the Great Kanawha and five on the Big Sandy rivers. These dams are divided into two parts, one called the pass, through which navigation passes when the dams are down, and the other the weir. The passes have their sills at a level approximating that of the river bed in the locality, while the weir sills are several feet higher, varying generally from 4 to 8 feet. These weirs are virtually stationary dams of small height surmounted by movable tops of the Chanoine wicket type, and their sills are placed higher than those of the passes in order to reduce the heights of the movable parts to limits within which they can be readily handled under the head of full or overfull pools. The wickets are 3 feet 9 inches wide and have a vertical height above sills of from 8 to 11 feet. On the Kanawha the wickets are both lowered and raised by means of a hand winch travelling on a trestle service-bridge, placed just upstream. On the Big Sandy a service-bridge is used in raising, but the wickets are lowered by means of tripping bars which pull the props sidewise away from their supports. A similar device was originally installed on the Kanawha weirs, but owing to faulty design it was a failure. The twenty-seven dams of the Belgian Meuse are equipped with tripping bars which have operated successfully for the past thirty-five years. The great advantage of this device is that the wickets can be thrown in ice or drift, from a safe operating position, without the least danger to operatives, wickets,

or service-bridge, the latter having been lowered at such time after raising the dam as desired, but certainly previous to the formation of ice or the appearance of drift.

Combination of Shutter and A-Frame.—In studying the question of the type of dam to adopt for a movable top it has occurred to the writer that a service-bridge made of A-frames, and the dam itself of Thenard shutters, would be a happy combination. The A-frames would, of course, be first raised, forming a service-bridge from which to raise the shutters, and at the same time they would shut the flow off so that the raising would take place in quiet water. After the shutters are up part or all of the A-frames could be lowered, thus bringing the head of pool against the dam proper. The A-frames, or service-bridge, could remain down until another raising of the dam is necessary, as the shutters will be lowered with the tripping bar. For pool regulation at times when there is a small rise a short length of the service-bridge can be left standing, from which as many shutters as desired can be lowered or raised at will. On the Big Sandy River weirs the wickets are raised by means of a stationary winch on the abutment, from which a wire rope passes out over the service-bridge to a sheave attached to a car, and around this sheave to the wicket. With the A-frame as a service-bridge it would be possible to attach the sheaves directly to the A-frames instead of to a travelling car. With this method, or combination, it would be possible to put on movable tops of great height, as the power required to raise the shutters in quiet water is easily developed; in fact, less power will be required than that now used for throwing the Big Sandy wickets with the tripping bar, which is moved by hand-power gear. The objection to the A-frame dam that drift or ice would interfere would, in this case, lose its significance, as it never would be necessary to lower the frames with drift or ice running. In fact, the chief objection to each of the two types is eliminated when they are used in combination, because the A-frame can be lowered at any time, even before the water reaches normal pool height, and the shutters can be raised without any pressure whatever coming against them during the operation.

In the opinion of the writer the combination suggested would, if properly designed and constructed, solve the problem of a movable top to stationary dams, or of movable dams in the broader sense, with greater success and satisfaction than anything so far tried, or suggested for trial, for either dams or tops.

A movable dam should not be raised against the current; and it should be lowered with the current by methods which will not endanger the lives of those engaged upon it, or injure the dam itself. When down, or when being lowered, it should offer no projections or parts which can cause injury by ice or drift. It should have very few moving parts. It is believed that the Thenard shutter is such a dam, when used in combination with an A-frame service-bridge.

Maj. C. A. F. Flagler
Corps of Engineers

A flashboard on a dam of a type easily operated from the bank possesses undoubted advantages, most of which are brought out in the article. One frequent use of flashboards is for local repairs to the downstream face of the dam during low water. In such cases flashboards, frequently improvised, are erected on or above the crest of the dam to prevent overflow for a short section. It would be an important improvement to this design if its operation could be extended to independent raising and lowering of short sections, or to independent operation by halves.

As regards obstructions to the operation of this dam, I believe there is little to fear from drift and logs. As the writer states, there is little drift at the low stages, and what there is could be easily removed. At the high stages, with the dam up, the smooth surface presented would offer little opportunity for drift to lodge under the heavy pressure of high-water discharge. I am inclined to fear obstruction more from the deposit of mud in silt-bearing streams, which might fill the entire recess provided for the dam, requiring the expense of frequent cleaning and, under some conditions, being almost impossible.

This dam is almost identical with one designed by Mr. B. F. Thomas, United States Assistant Engineer, and described by him in an article published in the Journal of the Association of Engineering Societies, June, 1896.

Maj. W. W. Harts
Corps of Engineers

The advantage in using movable dams in canalized rivers, especially where there is considerable range between the high and low water stages, is so obvious that engineers have been engaged for many years in an effort to devise a dam that would satisfactorily combine the good principles of theory with such practical design as would enable it to be successfully used on the various classes of streams met with both in this country and abroad. The great number of inventions proposed at various times attest the interest which has been taken in this class of work. It is unfortunate, however, that so few of these dams have met with success when practically applied, and that even those that are fairly successful under certain conditions should be found to be wholly inapplicable to others.

A prime necessity in all movable dams is simplicity, for when the dam is lowered the river flow passing over it will usually fill the smallest interstices with silt, leaves, and drift which will interfere with its manipulation if the dam is complicated.

The dam proposed by the author for increasing the height of fixed dams apparently differs in no material points from the A-frame dam proposed by Mr. B. F. Thomas, United States Assistant Engineer, some years ago, and adopted on the Upper Ohio at

Dam No. 6. It is said that this dam after its completion was only once lowered, and that before it could be again raised a cofferdam, from which the water could be pumped, was necessary so that the sand and gravel which had collected in the openings and over the frames could be taken out with picks and shovels. It is understood that this dam was never again lowered, and that it now acts as a fixed dam, losing all its advantages as a movable dam. There seems to be no reason why the dam proposed by the author should not be equally subject to a similar injury in any silt-bearing stream.

Furthermore, the use of long chains extending across the stream for raising movable dams has been tried and found to be of doubtful value. An early method of raising the trestles on the movable dam across the Big Sandy, at Louisa, Ky., was proposed at one time, by which a chain was to be used which passed through the heads of the trestles and was wound up on a drum on the abutment. Locking devices to raise and release the trestles, also similar to those indicated in the paper, were suggested by Mr. Thomas, and the writer was sent in 1893 or 1894, while an assistant in the Cincinnati office, to examine and report upon the methods proposed for raising and lowering this dam. The machinery was soon found to be too intricate, and the weight of the trestles and the friction of the chains too great, so that as a practicable method it was later abandoned, and the use of boats for raising and lowering the dam finally adopted. There seems to be no doubt but that the use of chains in cases like the one suggested would necessarily be of very limited application, and the construction of the intricate methods of locking the panels together, and of releasing and attaching them to the moving chain, would not be suitable for locations where all the moving parts could not be easily reached. At such locations other methods might be found better.

The fact that a similar dam, when actually constructed, has had such an unfortunate experience would be a good reason, in the minds of many engineers, for not adopting the same principle to the use proposed unless all the causes of past trouble were unquestionably avoided.

Capt. LYTLE BROWN

Corps of Engineers

Lieutenant Adams points out why this dam was not adopted in the Pittsburg District. If it were certain that one man could operate the dam, I do not think that its high first cost should condemn it. Serious trouble in operation would be almost a certainty, because of the great number of points, trouble at any one of which is possible and might totally block operation pending remedy. Any movable dam whose units fall across the current is sure to be a source of trouble in case of drift and ice during operation. Heavy ice in scraping across a crest sometimes drops a considerable quantity of sand, gravel, and boulders on the cest.

Mr. W. H. McAlpine

Assistant Engineer

The A-frame movable top to provide increased depths above fixed dams, designed by Lieut. Lewis M. Adams, Corps of Engineers, I believe could be used with success under the conditions described as existing on the Monongahela River at Lock No. 5.

The A-frame and mechanism appear to be exceptionally well designed and simple in operation. The top and recess of the fixed dam are well designed to prevent injury from drift and ice to A-frame when the crest is down. One of the best features of the movable top is that it enables the operators to lower the dam from the lock wall without danger of accident to themselves. The danger attached to lowering the ordinary movable crest with hinged trestles and needles from a maneuvering boat in a rapidly rising river full of drift, especially at night when the drift can not be seen, is considerable.

With no drift running there should be no difficulty in raising the crest of dam, and as the movable crest is used only for procuring additional depths of water at low stages of the river, it should be possible, with careful supervision, to lower the crest on the approach of a rise before sufficient drift appeared to interfere with the lowering of dam. As the author states, the only objection to this type of dam is the possibility of some of the mechanical parts becoming fouled by drift in lowering the crest during a rise. How much danger there is from this source and the practical success of this type of dam can only be determined by trial, but its obvious advantages over the ordinary type of movable crest, under conditions described by Lieutenant Adams in his paper, would seem to justify a trial.

For several reasons, the A-frame dam of Lieutenant Adams could not be adapted to the conditions at Lock No. 11, Kentucky River, where the dam has a 6-foot movable crest. At this lock the elevation of the fixed dam and the lower miter sill of the next lock above are the same, and at low water the draft over the lower sill at Lock No. 12 depends entirely on the extra height of water secured by raising the movable crest. After each rise it becomes necessary to raise the crest on about 3.3 feet of water passing over the fixed dam. At this stage of water, with crest down, the reading on lower sill at Lock No. 12 is slightly less than 6 feet, due to the 3.3 feet of water on dam plus elevation due to surface curve. Only a portion of the crest of the dam can be raised, as the four draining valves are not nearly sufficient to pass the large volume of water passing over the dam at this stage. In other words, the elevation of the pool and the consequent draft over lower sill at Lock No. 12 is regulated largely by raising or lowering a sufficient number of sections of the movable crest. When the movable crest of dam is up and the river starts to rise beyond the capacity of the draining valves, a few sections of the movable crest are lowered, and if this is not sufficient, addi-

tional sections are lowered, and again, as soon as the pool commences to drop below the crest, the required number of sections are raised to restore the pool to normal level. The pool could also be regulated by removing alternate needles or pushing back some of the needles at the top, but this is seldom done on account of drift.

Now, at this lock it would be necessary, a large part of the time, to have part of the A-frame dam down, and under these conditions the drift would accumulate around the mechanical parts of the sections partly lowered to such an extent as to obstruct the lowering of the remainder of the dam. The drift on the Kentucky River is exceedingly abundant, and it is not possible to maintain any sort of connection between the part of movable crest up and the part down. The movable crest on Dam No. 11 consists of 26 hinged trestles 6 feet in height, and spaced 8 feet apart, and when up connected by rails supporting the upper end of 2 by 4 inch needles. Originally, these trestles were connected by chains for the purpose of raising the trestles by hand, beginning at the lock wall, without the use of maneuvering boat. During the first winter when these trestles were down, these chains were completely worn out and broken by the constant surging of water in recess made in top of dam for receiving these trestles when lowered. Some of these chains were removed at the abutment end, but the chain connecting the last trestle in the down position was always broken by drift. It is therefore necessary to raise the trestles by grappling into them with grab hooks or other device. This is not an easy thing to do with 4 or 5 feet of water on dam, but a scheme has been devised by the lock men which is quite successful in accomplishing this.

In the foregoing discussion I have attempted to indicate the difficulties of adapting the A-frame crest to the conditions existing at Lock No. 11, often necessitating the maintaining of portions of the crest up to regulate the draft of water over lower sill at Lock No. 12, and incidentally to illustrate the difficulty attending the operation of any fixed dam under such exacting conditions. It is believed that most of the difficulties first encountered in the operation of the movable crest at Lock No. 11 have been overcome. My experience with the operation of a movable crest leads me to believe that they may be desirable adjuncts to provide additional draft at lower water discharge, under similar conditions described by Lieutenant Adams on the Monongahela River at Lock No. 5. The fixed dam is preferable to the movable crest for maintaining normal level where conditions will possibly permit.

The dams on the upper portion of the Kentucky River have an 18-foot lift at normal pool stage, with movable crest of dam up. The 6-foot movable crest, of course, decreases the first cost of the lock, less guard above normal pool being necessary. The reaction below dam during high water is not so great. The damage from backwater on low land in creek bottoms is also greatly diminished, which is an item of importance on the Kentucky River.

It would seem advisable where movable crests are resorted to, to establish the height of elevation of the fixed portion of dam at suf-

ficient elevation above the elevation of lower sill, so that it would be only necessary to raise the crest when the stage of water is fairly low, as a foot or two passing over the dam, or where most of the surplus water can be passed through the draining valves.

Lieut. L. M. ADAMS

Corps of Engineers

After looking over the copies of the discussions of the movable top described in the article, it would appear that too much consideration and weight has been given to the well known obstruction and failure of the A-frame dam which was installed as a movable weir at Dam No. 6, Ohio River, in 1899-1900. It should be borne in mind that the article describes a movable top to a fairly high fixed dam in contradistinction to an A-frame movable dam seated deep in the bed of a swiftly flowing river. Furthermore, the movable top was proposed for a particular stream, the Monongahela, which carries but a small amount of sediment in suspension and but very little floating drift even in time of high water, in which condition the movable top is down in its recess and entirely protected from obstruction. It was assumed from the first that the recess along the crest of the fixed dam would accumulate considerable very soft fine silt in the same way that the recesses for the gate machinery of the locks accumulate silt, but no trouble from this source in operating the movable top is anticipated, inasmuch as the fine silt in the gate-machinery recesses gives little or no trouble. No sand or gravel is ever found in these recesses.

The lock-master at Dam No. 6, Ohio River, Mr. R. C. McCullough, gave me a very clear written report on the failure of the 120-foot A-frame movable dam at this work, and I shall quote briefly from it:

> "There was a bar where the A-frame weir was built, which had to be removed, and it was also necessary to remove some of the bank, as you understand the weir is next to the shore. The bar reformed after the cofferdam was removed and at the present time is about even with the crest (standing position) of the A-frames on both upper and lower sides. The *gravel* and *sand* is banked up against the frames on both sides. The weir was never operated since the cofferdam was removed, and the openings beneath the A-frames are also filled with *gravel*. There is an eddy on the weir side of the river at all stages and everything seems to collect there, as we find from 2 to 3 feet of *gravel* every spring on the bear-trap leaves which are next to the A-frame weir."

From this report of conditions at Dam No. 6, Ohio River, it would seem unreasonable to condemn the A-frame principle for all locations and special applications. It would seem from the discussions preceding that at least a few features of the design for which originality might be claimed have been overlooked; that is, reducing the ratio of height to width of frames by one-half and thereby reducing the number of frames and accompanying mov-

able parts by one-half for the same length of dam; also, the eccentric loading of the frames so that they seat themselves by gravity in the last movement to the standing position; also, the large hatchet-shaped pawl to afford positive means of locking and unlocking the operating chain; also, the design of the last counterweighted abutment frame to maintain tension on the operating chain and thereby afford an automatic start in the operation of lowering the movable top as soon as the chain is slackened from the lock wall; and again, the design of the crest of the fixed dam to carry the movable top in the down position with a minimum depth of 1 foot of water above it for protection.

A NEW PORTABLE SEARCHLIGHT TOWER

BY

Lieut. W. H. ROSE

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In connection with the description of the German portable telescoping tower, published with illustrations in the article on "Field Searchlights" in the last number of the MEMOIRS, a recent development in this line may be of interest.

The manufacturer of the tower above referred to has recently put on the market an ingenious modification in which a three-part tubular mast is substituted for the wooden framework of the older type. The tubes telescope inside each other in the same manner as the sections of the wooden tower. The telescope mast lies in a horizontal position for transport, and can be erected in a vertical position previous to extending by rotating it around an axle mounted behind and above the rear axle of the carriage. The extension is secured by simple apparatus operating on the same principle as that described in connection with the wooden tower.

The upper section of the mast carries on its upper extremity a pressed sheet-steel fork with holes for the trunnions of the projector drum. For projectors up to 90 centimeters in diameter a single mast is used; for larger sizes a double mast with a cross-arm connection at the top supporting the projector. The single mast type is made from 7 to 9 meters in height and the double mast about 5.4 meters.

For the single mast it is claimed that the erection, adjustment, and extension can be effected by two or three men within two minutes, and that the reduction requires not more than fifteen seconds.

The masts are mounted on turn tables so that they can be revolved in azimuth, and the projector can also be turned in its trunnions. These movements can be effected either by hand or by electric motors.

SELECTED ARTICLES OF ENGINEERING INTEREST

Compiled by Henry E. Haferkorn, Librarian, Engineer School.

In the lists of selected articles published, the publication is referred to by the number preceding its title in the following list. The following abbreviations will be used: I, for illustrated; D, for diagrams.

(1) Annales des Ponts et Chaussees.
(2) American Machinist.
(3) Canadian Engineer.
(4) Canadian Society of Engineers. Trans.
(5) Cassier's Magazine.
(6) Cement.
(7) Cement Age.
(8) Cornell Civil Engineer.
(9) Electrical Review (London).
(10) Engineer (London).
(11) Engineering (London).
(12) Engineering-Contracting.
(13) Engineering Magazine.
(14) Engineering News.
(15) Engineering Record.
(16) De Ingenieur (Hague, Holland).
(17) Journal of American Society of Mechanical Engineers.
(18) Journal of Western Society of Engineers.
(19) Journal of Franklin Institute.
(20) Journal of Royal United Service Institution (London).
(21) Proceedings, American Society of Civil Engineers.
(22) Proceedings, Engineers' Club of Philadelphia.
(23) Municipal Engineering.
(24) Municipal Journal and Engineer.
(25) Railway Age Gazette.
(26) Revue Generale des Chemins de Fer (Paris).
(27) Scientific American.
(28) Scientific American Supplement.
(29) Transactions, American Society of Civil Engineers.
(30) Professional Memoirs, Corps of Engineers.
(31) Journal of the Royal Artillery (Woolwich, England).
(32) Royal Engineers' Journal (Chatham, England).
(33) Proceedings Brooklyn Engineers' Club.
(34) Concrete.
(35) Bulletin de la Presse et de la Bibliographie militaire (Brussels).
(36) Internationale Revue ueber die gesamten Armeen und Flotten (German and French). (Dresden.)
(37) Revue d'Artillerie (Paris).
(38) Kriegstechnische Zeitschrift (Berlin).
(39) The Contractor.
(40) Cement Era.
(41) Canal Record (Ancon, C. Z.).
(42) Proceedings, Engineers' Society of Western Pennsylvania.
(43) Journal, United States Artillery.
(44) Transactions, Society of Engineers (London).
(45) Journal, Association of Engineering Societies.
(46) United States Naval Institute. Proceedings.
(47) Revue du Genie Militaire (Paris).
(48) La Technique Moderne (Paris).
(49) Electrical World.
(50) Electrical Review (Chicago).
(51) Journal, Military Service Institution.
(52) Barge Canal Bulletin.

ARMOR PLATE.

The Krupp Works. C. Van Langendonck. (13), March, 1911. I.—The works of John Cockerill, Seraing, Belgium. (10), Dec. 23, 1910.

BARGES.

Concrete barges for the Panama Canal. M. E. Rupp. (40), Feb., 1911. I.—Petrol-driven oil tank barge. (10), Feb. 19, 1911. D. I.

BREAKWATERS.

Methods and cost of constructing stone filled timber breakwater, Lincoln Park extension, Chicago. (12), Feb. 22, 1911. D.

CAISSONS.

Caisson for the new Quebec bridge. (10), Jan. 6, 1911. I.

CANALS.

Another canal report. (10), Jan. 27, 1911.—Bruxelles maritime. E. Guarini. (Revue Technique.) Nov. 25, 1903.—Canadian hydraulic lift locks on the Trent Canal system. (10), April 29, May 13, 20, June 10, 1910. D.—Le canal maritime de Bruxelles. L. F. (46), Dec., 1910. D.—The Cape Cod canal. J. W. Miller. (12), January 4, 1911. D.; (14), December 15, 1910. D.—Chesapeake and Delaware Canal in the Civil War. R. R. Raymond. (30), April, 1911.—Disposal boat for canal work. (39), March 1, 1911. I.—Draining the Everglades. D. A. Willey. (27), Jan. 21, 1911. I.—Fluctuations of water level in a canal caused by the filling of locks. L. C. Sabin. (30), April, 1911. D.—Management of the New York Barge Canal. (15), Dec. 31, 1910.—North Shore drainage canal at Chicago. (14), Jan. 5, 1911. I.—Paris as a seaport. (10), Jan. 6, 1911.—Paris as a seaport. Proposed canal between Paris and Rouen. (28), Feb. 4, 1911. D.—The Paris ship canal. (10), March 3, 1911.—Les nouvelles installations du port de Bruxelles. M. Roux. (Le Genie Civil), Jan. 12, 1907. I.—Water supply for British canals. (11), Jan. 20, 1911.—Work on St. Martin Canal, Paris. (27), Dec. 31, 1910. I.

CEMENT.

Cement in the Tropics. K. E. Engeworth. (32), Feb., 1911. D.

COAST CHANGES.

Coast erosion. J. S. Owens. Note. (10), Jan. 13, 1911;—(11), Feb. 24, 1911; (10), March 3, 1911.

COAST DEFENSE.

Effects on coast defense of the naval developments of the last few years. C. R. Buckle. (31), Nov., 1910; the same, H. T. Hart. (31), Sept.; (43), Nov.-Dec., 1910.—Old battleships as permanent forts. (27), March 11, 1911. I.—Type of gun for coast defense; Type of weapon for coast armaments. (31), Feb., 1911.

COFFERDAMS.

Clay pressures and steel cofferdams. (14), Jan. 12, 1911. D.—Design of cofferdams for deep water. (14), Jan. 12, 1911.—New lock and dam No. 5, Monongahela River. L. M. Adams. (30), April, 1910. D. I.

COLUMBIA RIVER.

The great river of the Northwest. K. L. Smith. (28), Dec. 17, 1910. I.

COMPRESSED AIR.

Draining of compressed air. F. Richards. (15), Feb. 18, 1911.

CONCRETE. Plain and Reinforced.

Action of mine water on concrete. (15), Jan. 21, 1911.—Basis of design for flat concrete floor slabs. A. R. Lord. (15), Dec. 24, 1910.—Big concrete work on King's Creek power plant. (40), March, 1911. I.—Bond-friction-resistance in reinforced concrete. Discussion. E. Godfrey and others. (21), Dec., 1910.—Building a concrete bridge under difficult conditions. W. M. Denman. (15), Feb. 25, 1911. I.—Building concrete arches in cold weather. (15), Jan. 21, 1911. D.—A complete floating concrete plant. L. M. Adams. (30), Jan. 15, 1911. D.; (40), Feb., 1911. D.—Concrete barges for the Panama Canal. M. E. Rupp. (40), Feb., 1911. I.—Concrete plant on Panama locks. Description of machinery and methods of operation in construction of walls of the three Pacific locks. (39), Feb. 15, 1911.—Concrete protection coating for a small tank tower. (14), Jan. 5, 1911. I.—Concrete-steel piers at Baltimore. (39), Dec. 15, 1910.—Concrete tables and tanks for a laboratory. W. K. Hatt. (14), Feb. 23, 1911. D. I.—Design and computations for a cellular reinforced concrete dam. G. J. Bancroft. (12), Dec. 14, 1910. D.—Design and equipment of a floating concrete plant with costs. L. M. Adams. (12), Feb. 1, 1911. D.—Designing concrete abutments for steel highway bridges. H. E. Bilger. (14), Feb. 16, 1911. D.—Effect of electrolysis on metal embedded in concrete. (15), Dec. 24, 1910. (12), Jan. 25, 1911.—Electrolytic corrosion of iron in concrete. (15), March 11, 1911.—Expanded steel for reinforced concrete construction. (32), March, 1911. D.—Flexible chute for depositing concrete. (15), Jan. 14, 1911. I.—Forms for concrete. Schemes for saving time, labor, and lumber. (28), Jan. 14, 1911. D. I.—Handling concrete in cold weather. J. H. Chubb. (39), Dec. 15, 1910.—Handling concrete on canal locks. (40), March, 1911. D.—Large reinforced concrete beam on the New York

Barge Canal. (15), Jan. 7, 1911. D. I.—Motor boat of reinforced concrete. A. Scheible. (40), Feb., 1911. I.—New lock and dam No. 5, Monongahela River. L. M. Adams. (30), April, 1910. D. I.—New system of mixing, conveying, and distributing concrete. (39), Jan. 1, 1911. I.—Novel system of concrete reinforcement. (14), March 9, 1911. D.—Precautions should be taken with concrete in cold weather. J. H. Chubb. (34), Feb., 1911.—Reinforced concrete reservoir at Kensington, Conn. A. W. Bacon. (15), Feb. 18, 1911. D. I.—Replacing a steel viaduct with concrete arches. (15), Jan. 14, 1911. I.—Simple formula for calculating the strength of reinforced concrete beams. T. E. Kelsall. (32), Feb., 1911. Some tests on ligno-concrete. C. A. M. Smith. (11), Dec. 16, 1910.—Some thermal properties of concrete. C. L. Norton. (15), Dec. 24, 1910; (12), Jan. 4, 1911; (40), Jan., 1911.—Test of a flat slab floor in a concrete building. A. R. Lord. (15), Dec. 24, 1910. D. I.—Tests of soft soap for waterproofing concrete. (15), Feb. 25, 1911. I.—Tufa concrete. J. B. Lippincott. (15), Dec. 31, 1910. D.—Waterproofing the New Ulm concrete reservoir. (15), Dec. 17, 1910. D. I.

CONDUITS AND DUCTS.

Underground conduit construction. D. A. Harrington. (30), April, 1911. D. I.

CRANES, HOISTS, ETC.

25-ton steam travelling crane for harbor works, Singapore. (11), Jan. 13, 1911. I.—150-ton electric crane shipping the aft mast of the *Diderot*. (11), Dec. 23, 1910. I.

DAMS.

Arresting the flow of a large tidal river. The Charles River dam. J. A. Holmes. (14), March 9, 1911. D. I.—The Aziscohos reservoir dam, Rangeley Lake region, Maine. S. A. Moulton. (39), Jan. 1, 15; Feb. 1, 1911. D. I.; (12), Jan. 4, 1911. D.; (14), March 9, 1911. D.—Big concrete work on Kings Creek power plant. (40), March, 1911. I.—The Carson River dam. (15), Feb. 18, 1911. D. I.—Comment on "reversed" dams. E. Godfrey. (12), March 8, 1911.—Construction of the Roosevelt Dam. C. W. Smith. (15), Dec. 31, 1910. D. I.—Criticism of a cellular dam design and a discussion of "reversed" dams. R. C. Beardsley. (12), Feb. 1, 1911. D. I.—Curved concrete dam at Auckland. (15), Jan. 28, 1911.—Dams on sand foundations: some principles involved in their design. A. C. Koenig. (21), Jan., 1911. D.; (12), March 8, 1911. D.—Design and computations for a cellular reinforced concrete dam. G. J. Bancroft. (12), Dec. 14, 1910. D.—Failure of the Yuba River debris barrier, and the efforts made for its maintenance. Discussion. W. H. Harts and W. C. Hammatt. (21), Dec., 1910. D.—Geology and dam construction. (15), Jan. 7, 1911.—Howden dam. Derwent Valley works. (10), Jan. 6, 1911. I.—Impounding dam at Loch Arklet. (10), Jan. 6, 1911. I.—Increasing an Ohio River rise by drawing water from the Kanawha. T. E. Jeffries. (15), Jan. 28, 1911. I.—An A-frame movable top to provide increased depths above fixed dams. L. M. Adams. (30), April, 1911. D. I.—New water supply for Auckland, N. Z. (10), Dec. 30, 1910. D. I.—Problem of the high masonry dam. R. Ryves. (10), Feb. 24, March 3, 1911. D.—Progress and costs of filling for the Gatun Dam, Panama Canal. (12), Dec. 21, 1910. D.—Reconstruction of Marshall Lake dam. I. G. Harmon. (15), Dec. 24, 1910. D. I.—Right to use flashboards on dams. (15), Jan. 7, 1911.—The flow of water over dams. G. S. Williams. (14), Jan. 12, 1911. D.

DEMOLITIONS.

Demolition of the Hunho Railway bridge. Capt. Zavadski. (32), Dec., 1910. I.—Wrecking a bridge by electricity. (27), Jan. 28, 1911. D. I.

DERRICKS.

A swinging hand derrick for construction work. (14), Feb. 23, 1911. I.

DISPOSAL BOAT.

Disposal boat for canal work. (39), March 1, 1911. I.

DOCKS.

Modern electrical equipment for docks. W. Dixon and G. H. Baxter. (11), Jan. 27, 1911. D. I.; (10), Jan. 27, 1911.—Proposed improvements of the Port of London. (10), Feb. 10, 1911. D.; (11), Feb. 3, 1911. D.—Widening of the passage between docks at Barrow-in-Furness. (11), Jan. 20; Feb. 17; March 3, 1911. D.

DREDGES AND DREDGING.

Clay-cutting hydraulic dredger for the River Nile. (11), Jan. 6, 1911. I.—Dis-

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Earth pressures. C. K. Mohler. (18), Dec., 1910. D.

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Effets des tremblements de terre sur les constructions. (48), Feb., 1911.

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Notes on the embarkation and disembarkation of mules. T. A. Swinburne. (32), Feb., 1911. D.

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A chart for the calculation of engineering formulas. M. E. J. Gheury. (10), Feb. 24, 1911. D.

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Science and engineering. Sir J. J. Thomson's comments on a vital subject. (11), Nov. 18, 1910; (28), Jan. 28, 1911.

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The U. S. Assistant Engineers. (15), Dec. 17, 1910.

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The Corps of Engineers in Napoleon's "Grand Armee." G. M. W. MacDonogh. (32), Jan., 1911.—De technische opleiding van den Genieofficier. (16), Jan. 7, 1911. I.—Territorial training of engineers under the compulsory system in New Zealand. J. E. Duigan. (32), Feb., 1911.

EXCAVATION AND EXCAVATORS.

Digging ditches with dynamite. A. E. Morgan. (12), Feb. 1, 1911. I.—Ditching and trenching machinery. E. E. R. Tratman. (39), Feb. 1, 1911.—Excavating machinery for ditching and trenching. E. E. R. Tratman. (14), Feb. 23, 1911. I.—Excavating the pit for a third lock at Sault Ste. Marie. (15), Jan. 7, 1911. I.—New Monahan trench machine. (39), Jan. 1, 1911. I.—A new trench-excavating machine. (15), Jan. 14, 1911. I.—New type of excavator used on the North Shore Drainage Canal, Chicago. (12), Jan. 18, 1911. D. I.

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Explosive don'ts. (15), Feb. 25, 1911.—Precautions in the use of explosives. (28), March 11, 1911.—Regulation for the transportation of explosives. B. W. Dunn. (12), Dec. 28, 1910.—Rosyth explosives works. (10), March 3, 1911.—Safe transportation of explosives. B. W. Dunn. (39), Dec. 15, 1910.—Use of chlorates in commercial explosives. A. L. Jones. (14), Jan. 5, 1911. D.—Warning to contractors regarding shipments of explosives. Letter to ed. (15), Dec. 24, 1910.

FLASHBOARDS. (See Dams.)

FLOODS.

Failure of the Yuba River debris barrier, and the efforts made for its maintenance. Discussion. W. H. Harts and W. C. Hammatt. (21), Dec., 1910. D.—Proposed flood protection plans for the Maris des Cygnes River, Kansas, with estimates of costs. (12), Feb. 1, 1911. D.

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Firing and detonating trials against modern fortifications. Trans. H. L. Wigmore. (43), Nov.-Dec., 1910. I.

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Fuel oil vs. coal. S. E. Lawrence. (30), April, 1911.

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Great Western Harbor at Fishguard. (10), Dec. 16, 1910. I.—Harbours and harbour works. (11), Jan. 27, 1911.—Improvement of port facilities at Kobe harbor, Japan. H. McL. Harding. (14), March 2, 1911.—The "Longer pier" controversy at New York. (27), Feb. 4, 1911. D.—Necessity of longer piers for the port of New

York. C. Tomkins. (27), Feb. 18, 1911. I.—Notes on the Bar Harbors at the entrances to Coos Bay, and Umqua and Siuslaw rivers, Oregon. L. M. Haupt. (21), Jan., 1911.—Operation of rock breakers at Black Rock Harbor, Buffalo, N. Y. (15), Jan. 7, 1911. D. I.—Port of London improvements. (15), Feb. 25, 1911.—The Port of New York. (15), March 11, 1911.—Le projet de Paris-port-de-mer. (48), Feb., 1911. D.—Proposed improvements of the Port of London. (10), Feb. 3, 10, 1911. D.; (11), Feb. 3, 1911. D.—River and harbor improvements and the Corps of Engineers. Extracts from an address by Gen. W. H. Bixby. (15), Dec. 24, 1910.—Terminal facilities in their relation to waterway improvement. G. A. Zinn. (30), April, 1911.—25-ton steam travelling crane for harbor works, Singapore. (11), Jan. 13, 1911. I.

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The flow of water over dams. G. S. Williams. (14), Jan. 12, 1911. D.—Flow of water through submerged screens. (15), Dec. 31, 1911.—Surges in pipe lines. F. G. Baum. (15), Dec. 24, 1910. D.

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Hydrography as an aid to the successful operation of an irrigation system. Discussion. E. F. Chandler and others. (21), Dec., 1910.

INLAND NAVIGATION.

Economic value of waterway transportation with reference to the proposed Deep waterway from Chicago to the Gulf. (12), Jan. 11, 1911.—The passing of the waterway boom. (14), March 2, 1911.—Report of a Board of Engineers on the Illinois section of the Lakes-to-the-Gulf waterway. (14), March 2, 1911.—Terminal facilities in their relation to waterway improvement. G. A. Zinn. (30), April, 1911.—The waterway from Chicago to the Mississippi. (15), Feb. 25, 1911.—Waterways—their limitations and possibilities. F. A. Delano. (12), Jan. 11, 1911.

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General description of the depression position plotter. D. E. Hughes. (30), April, 1911. D. I.

LANDSLIDES.

Report by a geologist on slides in Culebra Cut and by a Board of Engineers on the revetment of the sides of the cut. (14), Jan. 5, 1911.

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A new automatic flashing light. (10), Dec. 23, 1910. I.

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Concrete plant on Panama locks. Description of machinery and method of operation in construction of walls of the three Pacific locks. (39), Feb. 15, 1911. D.—Emergency gates on the Illinois and Mississippi Canal. (14), Dec. 15, 1910. D.—Excavating the pit for a third lock at Sault. Ste. Marie. (15), Jan. 7, 1911. I.—Handling concrete on canal locks. (40), March, 1911. D.—Methods and costs of constructing concrete masonry for the Pedro Miguel and the Miraflores locks of Panama Canal. (12), Dec. 14, 1910. D.—Methods of constructing the Black Rock Harbor Lock, New York Barge Canal. (12), Jan. 4, 1911. D. I.—New Canal Gate at Sault Ste. Marie. (15), Dec. 10, 1910. D. I.—New Lock and Dam No. 5, Monongahela River. L. M. Adams. (30), April, 1910. D. I.—Renewing lock gates on Kanawha River. T. E. Jeffries. (15), Dec. 24, 1910. I.—Valve-operating mechanism for the Panama Canal locks. (15), Jan. 7, 1911.

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Bridging operations at Harty Ferry. J. C. Matheson. (32), Feb., 1911. I.

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Military Engineering. C. W. Otwell. (22), Jan., 1911. I.—Work of the Corps of Engineers, Ohio National Guard. From report of J. R. McQuigg. (30), April, 1911. I.—Work of the Royal Engineers in the China or Boxer war of 1900-1901. F. T. N. S. Bowring. (32), March, 1911.

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Observation land mines. L. Debogorii-Makrievich. (32), Feb., 1911. D.

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Editorial Notes

Ownership of Tide Lands

The following syllabus and abstracts of decision in the Superior Court of California by Judge Walter Bordwell, Los Angeles, Cal., are of wide interest to all officers and assistants engaged on river and harbor work. It contains over twenty thousand words and represents a year's hard work and study by one of the ablest judges in California. Two copies are now on file in the Engineer School Library, and it is proposed to obtain several more, all of which will be available to loan to officers desiring to study the full decision.

There are three fundamental truths brought out in the decision which are believed worthy of particular attention.

First. That certain powers and rights are inherent in the sovereignty of a State, and can not be taken away or abridged without impairing that sovereignty. Instance the right of a State to control and use the harbors and waterways within its borders and to have free access thereto.

Second. That the people of a State have certain natural rights which the State itself may not deny them—as the right to use the tide lands of the State for purposes of navigation.

Third. That a deed in fee simple or a grant, or even a lease which impairs a natural right of the public, such as the free use of harbors and waterways and access thereto, is void.

In the specific case decided by Judge Bordwell, the defendants claimed certain tide lands in San Pedro (Los Angeles) Harbor, Cal., by virtue of State patents granted through a perversion of California State laws authorizing the sale and reclamation of swamp and overflowed lands. These California State laws were based on a United States law passed on the 28th of September, 1850, and commonly known as the Arkansas Swamp-land Grant, by which the United States Government granted to Arkansas, and each of the other states then in the Union, all the swamp and over-

flowed lands within their respective borders. It was provided by the act "that the proceeds of said lands . . . shall be applied, exclusively, as far as necessary, to the purpose of reclaiming said lands by means of . . . levees and drains."

* * * * * * *

1. The history of the English law of titles to lands beneath the tidal waters is instructive and of important bearing on the question of the power of the State in the premises. But an attempt to state even its outlines would unduly prolong this opinion. The modern doctrine, obtaining in England since the Seventeenth Century, declares the title to lands over which the tide flows up to ordinary high tide line to be in the sovereign, not as proprietary lands and subject to sale, as are the uplands, but to be held by the sovereign as the representative of the nation, remaining in him and in his successors, as long as the Kingdom shall endure, as a royal prerogative, and as such, not ordinarily subject to alienation.

The high seas are nature's great highways for the common use of all peoples of all countries. It is so recognized by the laws of nations. The free use of the foreshores of the seas ought to be open to all citizens. This right of such use is an integral part of the common law, based primarily upon the proposition that it is a law of nature. By the rules of the Civil Law the shores of the sea (tide lands), as well as the sea itself, were declared to be common to all men by the law of nature, and were classed among those things that can not lawfully belong to individuals—the same as air and running water (Justinian's Institutes, liber 2, title 1, Sec. 1).

In this country the courts from the beginning adopted the doctrine that the title to the lands under the flow of the tides is vested in the State as the sovereign prerogative; or, as it is frequently expressed, such title is possessed by the State by virtue of her sovereignty. This tenure, by which the state is said to hold title to the tide lands, has been characterized by the courts of this country as "a title held in trust for all the people."

* * * * * * *

I understand this statement to mean that the people in their collective capacity organized as a state, hold title to the tide lands in trust for all of the citizens, severally or individually, to the end that they and each of them may freely enjoy the use thereof for purposes of navigation and fishery. It does not mean, however, that limited rights or privileges to the foreshores may not be granted to individuals or corporations when the interests of the public may thereby be advanced and the rights of the citizens to pass and repass thereover and other use thereof are not substantially abridged. Nor does it inhibit the investment of qualified rights therein to owners of abutting uplands by appropriate legis-

lative action. Nor does it mean that the shores of navigable waters may not be forever alienated and conveyed into private ownership where they are useless for navigation purposes, or where their use for other purposes will be of greater public advantage or benefit.

It was in recognition of the principle that shores of tide waters may be alienated into private ownership, when a greater public benefit will result, that a large area of the mud flats of the city of San Francisco, constituting a considerable part of the shores of the bay, were conveyed into private ownership and devoted to commerce by special legislative act prior to the adoption of the present State Constitution.

At a given time or place it may prove to advance commerce and create public interest in navigation to permit private owners to erect piers and docks and other commercial facilities on the tide lands. Under such circumstances the permission for the erection of such structures may be given, *provided* the use of the seas and shores by individual citizens be not substantially abridged. But such permission is revocable, on just terms, at any time at the will of the state.

And so it is recognized by all authorities that, under some circumstances, where it will be to the public advantage, the shores of navigable waters may be conveyed by the state into private ownership, or the state's supervision thereover may be delegated to municipalities, or, subject to proper limitations as to time and under proper restrictions as to use, to private persons or corporations. And the courts of England recognize the power of the crown to convey the shores of the sea and its inlets, i. e., the lands below ordinary high tide line, into private ownership, subject, however, to unrestricted use of the waters for navigation by the public. And this power of disposition, subject to such use, is recognized by the courts of this country.

Counsel for defendants call attention to the principle that the power of the state legislature in governmental matters is unlimited, save by expressed constitutional restrictions, and, therefore, they argue, it is the province of the legislature to alienate into private ownership all lands over which the tide ebbs and flows, if deemed wise. This doctrine of the extent of legislative power is well understood by those instructed in Constitutional Law. But the question naturally arises, "Is such alienation of tide lands a governmental matter?" Some things the legislature may not do though the constitution contains no express prohibition. Omission of prohibition does not necessarily confer power. * * * Some judges and some prominent textwriters have expressed the opinion that with the assent of Parliament the crown might grant into private ownership lands beneath tidal waters which are useful for navigation. This is to be seriously doubted. Certain principles there are, the existence of which the state must recognize as essential to the protection of the individual and the minority in the blessings

with which they are endowed by nature. It is axiomate that what is common can not be owned in severalty.

A state, as a political institution, exists to preserve to the members of society that which they inherit as a natural right. It is the province of the state not to deprive man of the enjoyment of nature's gifts, but to insure him of her bounties. The legislature is but an instrumentality used by the state in aid of that object. And such a right—such a gift of nature—is the right to free and untrammeled use of tide lands. They are essential to, and as important as, the use of the seas. It is the province and duty of the courts to declare unlimited and unrestricted alienation by the state of tide lands subversive of the fundamental rights of the individual and any law purporting to authorize it void.

To permit such alienation would be, in effect, a denial of the existence of the trust in the state for all the people. It would be the alienation of one of the sovereign prerogatives which can never be allowed because *pro tanto* destructive of the very purpose for which the state organization exists. Title to tide lands "is an incident and part of its sovereignty that can not be surrendered, alienated or delegated, except for some public purpose or * * * benefit." (Coxe vs. State, 144 N. Y., 396.)

* * * * * * *

I. C. R. R. Co. vs. Illinois, 146 U. S., 387:

* * * * * * *

In the Illinois case, *supra*, it was unequivocally declared that the act of the legislature of Illinois *revoking* a grant (unreserved in its terms) of lands lying beneath navigable waters and along the shore of a harbor was legal and effective. The court there recognized, by most positive terms of expression, the doctrine that the state's holding of land underneath navigable waters was in trust for the people and that it was not in the power of the legislature to grant it away to private owners.

* * * * * * *

It can not be denied that the various acts of the legislature (of California [Editor]) from 1855 to 1863 were constructed in a manner well calculated to confuse. The drafting thereof was often inaccurate and indefinite; loose and ambiguous terms were frequently employed, tending to obscure the real purpose or legislative intent. But the mind of the legislature can be discovered by attentive study of the provisions of these various acts considered together. The intent must be gathered from a consideration of all that was said by the legislature on the subject, as incorporated in the various acts passed during this period covering several years. And what was said must be considered in the light of the aforementioned fundamental principles of the common law and the recognized rights of individuals under natural law.

Where such rights of the people are involved no act of the legis-

lature shall be construed as intending to deprive them thereof in any degree, unless it be couched in language which permits of no other honest construction. It is a very old rule of construction, familiar to students of the common law of England, that all grants by the crown are construed most strongly against the grantee and in favor of the crown. In this country the state takes the place of the crown—the state is here the sovereign. * * *

In the case of People vs. Russ, 132 Cal., 102, it appears that certain non-navigable sloughs threading a tract of swamp and overflowed lands had been purchased under the law authorizing it and patent issued; that in prosecuting the work of reclamation of the tract dams were constructed across the sloughs which were tributary to a navigable tidal stream. It was held that the owner of the land granted had no right to dam the sloughs, if the navigability of the stream was thereby materially impaired, and that such dams would constitute a public nuisance, abatable at the instance of the state. It is to be noted that this case, in effect, determines that even a grant of title to sloughs threading tracts of swamp and overflowed lands passes only a qualified title, and they may not be used by the owner in a manner which will substantially interfere with the navigability of adjacent tidal waters.

As evidence of the high regard which the law has for navigation, the court remarks in the opinion in this case: "While the state is pleased to see its swamp and overflowed lands reclaimed, and thereby become productive, yet the constitution of the state declares that no owner of tide lands of any harbor, bay, inlet, estuary, or other navigable water in this state, shall be permitted to destroy or obstruct the free navigation of such water. (Const. Art. XIV, Sec. 2.)"

The case of the People vs. Kerber, reported in 152 Cal., 731, has important bearing on the issues of the case before the bar. The property involved was certain tide lands situated in the city of San Diego and lying between ordinary high tide line and the line established by the harbor commissioners of San Diego for the location of a seawall, about 150 feet distant. * * *

* * * The principal point of decision in this case was whether or not title to such lands could be acquired by adverse possession. Of this the court declares: "Property thus held by the state in trust for public use can not be gained by adverse possession, and the statute of limitations does not apply. * * * This is the settled rule."

During the pendency of the application of Banning for the purchase of tide land location No. 69 a contest arose between him and one Learned as to who had the better right to make the purchase. * * * judgment being rendered to the effect that Banning "has

the right and is entitled to purchase of the State of California and to hold the land described in his affidavit and application,'' describing the land by meets and bounds, ''saving and excepting therefrom that portion thereof described in the affidavit and application'' of Learned, which was duly described, right to purchase which was adjudged in him.

And now it is claimed by the defendants that the judgment thus entered by the Superior Court was and is not only binding upon the parties, but also that the state is thereby estopped to thereafter claim the patent to be void for want of power of the legislature to authorize the sale or that there is no law offering such lands for sale.

* * * * * * *

The title can not rise above its source. If there be no law permitting the sale of state lands of a certain character, no decision of the surveyor-general, nor of the court in actions to which the state is not a party, can make the patent effective to carry title.

* * * * * * *

The controversy in the case of Ward vs. Mulford, reported in the 32nd California, page 365, involved certain tide lands included in a Mexican grant, which was confirmed by the Commission appointed by the act of Congress, March 3, 1851, * * * and patent issued accordingly.

The question whether or not Mexico, as a sovereign state, could lawfuly alienate tide lands does not appear to have been considered. * * *

Teschemacher vs. Thompson, 18 Cal., 11.

* * * If the title to tide lands, passed by the United States patent under the circumstances presented in the Teschemacher and the Ward case, is vested beyond revocation, it is upon the principle of *res adjudicata,* and not because the question of the power of the sovereign state to alienate tide lands has been decided by them. No case has been found which holds that any sovereign state has, or ever did have, the absolute power to alienate into private ownership in fee simple absolute tide lands which are useful for purposes of navigation.

The defendants' claim of title, by reason of undisturbed possession, and their plea of statute of limitations, and their plea of

estoppel against the plaintiff, growing out of the fact that they have long possessed the land in question and have constructed extensive and costly improvements thereon, must each and all be disallowed.

* * * * * * *

On the question of title by adverse possession the court in the Kerber (152 Cal., 731) case quotes with approval from another case: "There can be no adverse holding of such land which will deprive the public of the right thereto * * * The rule is universal in its application. * * * The same principles which govern the adverse holding of a street, public square, a quay, a wharf, a common, apply to the adverse holding" of a school house or other property held for public use. "The public is not to lose its right through the negligence of its agents nor because it has not chosen to resist an encroachment by one of its own number, whose duty it was, as much as that of any other citizen, to protect the State in its right." And, again, the court says in the same case: "So long * * * as property of this character (tide land) remains subject to use for the purposes of navigation it can not * * * be disposed of by the state in any way except in furtherance of the purposes of navigation to which it is dedicated."

Finally it may be stated as a general proposition that neither the plea of the statute of limitations nor of adverse possession is ever available as a defense to an action by the state to recover possession of or quiet title to property devoted to public use or held in trust for that purpose.

* * * * * * *

The state is not to be deprived of its right to assert title of which it has never been divested, merely because Mr. Banning and the state officials were ignorant of the fact that there was no law permitting the sale of the land. Under such circumstances it cannot be said to be a hardship upon the purchaser who, without legal right, has attempted to possess himself of title to the lands, for, the sale of which there was no law.

* * * * * * *

Some amount of attention has been given by counsel to the subject of reclaimability of the lands involved in this action. It is hardly worthy of serious consideration. "Reclaimability," as the term is used in the statutes herein reviewed, has reference to the redemption or protection of the lands offered for sale from

inundation, to the end that they may be used for agricultural purposes. The very term itself would suggest such purpose.

* * * * * * *

The suggestion that Mr. Banning applied for these lands with the view of reclaiming them for agriculture is an impeachment of his common sense. That he sought to acquire them with a view to their ultimate value for commerce is a credit to his far-sightedness and business sagacity. That such was his purpose, no reasonable man can doubt.

* * * * * * *

A grant of a franchise to private persons to operate a street railroad in a public highway is not a perversion of the use of the highway, but, rather, aids the public use thereof. But a purported grant by the state or its municipalities of the fee of a street, the use of which is indispensable or important to the public would be absolutely void. So also would a lease or other transfer of a street for a limited time (no matter how short), the purpose whereof is to vest exclusive dominion in the lessee or transferee. And upon reason, this must also be true of tide lands.

* * * * * * *

A "lease," as the term is ordinarily used, means a grant of absolute and complete dominion (except as to waste) against all the world over the land leased during the term. Such a grant is as much against the policy of the law as any other. Leases of such lands by the state or authorized municipalities are sufficient to give lessees a right of possession against a squatter; but, upon principle and the authorities cited, as between the state or the municipality and the lessee, the lease is but a permit and revocable at any time without compensation if no improvements have been made, otherwise by the payment of the just value thereof.

* * * * * * *

Much evidence and argument has been presented to the question of the proper location, on the ground, of ordinary high tide line, and also the correct depth of the water at ordinary high tide above datum line. And the court has given the question much study. In view, however, of the conclusions arrived at on other involved problems, a determination of the disputed point as to the depths of the water at ordinary high tide above datum is immaterial. And it suffices, for the purposes of this case and the other cases, to determine that ordinary high tide line is coincidental with the boundary line of Los Palos Verdes Rancho

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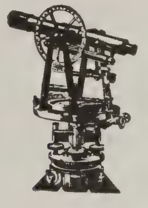

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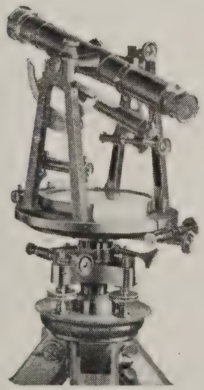

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on the westerly side of the channel and of the Rancho San Pedro on the western and northern sides of the inner bay.

* * * * * * *

Some of the tide land locations involved in these actions have been extensively filled in by the several claimants. This has been done without consent of the State, but, on the contrary, with knowledge on the part of all claimants that the State denied their claims to ownership in toto. This filling in in no way helps the cause of any claimant. Nor does it, in the slightest degree, add any equity calling for consideration.

A summary of conclusions from these considerations is as follows:

1. As a general proposition, tide lands which are immediately, or in the future, will be useful for navigation are not the subject of private ownership. They are held in common—the state is vested with title as trustee. The state ought not to, and can not without violence to the purposes for which it exists, alienate into absolute private ownership such lands. Such alienation would be an infringement upon the natural rights of the individual, and, therefore, subversive of the purposes of organized government. It would also be a surrender of an attribute of sovereignty, an abrogation of a vital political function. It is, therefore, forbidden.

2. The state may alienate into private ownership title to tide lands which are useless for navigation. It may also so alienate the title to tide lands for use other than navigation, when a greater public benefit will result.

3. The state may also grant franchises for constructing and maintaining wharves and docks for reasonable time and under proper terms and restrictions, and otherwise vest in private individuals or corporations a qualified or limited right in the use of tide lands when the right of the general public to such use is not substantially diminished and when navigation will be thereby aided and the public advantage subserved. Mere permits or licenses to use such lands are subject to revocation at any time at the will of the state or its municipal subdivisions, authorized thereto upon payment of reasonable value of improvements (if any) placed thereon by the licensee.

4. The general statutes and the code provisions passed by the legislature, and in force from 1858 to 1907, permitted the sale of tide lands when the same were unuseful for navigation and were so situated that they naturally formed an integral part of a tract

of swamp and overflowed lands and were reclaimable therewith. That the sale of no other tide lands was ever provided for by such statutes.

5. No statute of limitations has run against the plaintiff's right of action.

6. That such lands as are involved in this action are not the subject of acquisition by adverse possession. That the state is not estopped to maintain the action.

7. That portion of the land involved, lying north of the center line of Fourth street in the city of San Pedro, was excluded from sale by the terms of the general statutes and code provisions, being, at the time Mr. Banning procured his certificate of purchase, within two miles of the city of Wilmington as incorporated by the special legislative act of 1872.

8. The tide land in question is not reclaimable within the meaning of the statutes bearing upon that subject.

9. Tide lands which are not subject to sale are not subject to lease, whereby exclusive dominion would be vested in the lessee for a term named.

Let judgment be entered for plaintiff.

WALTER BORDWELL, Judge.

January 3rd, 1911.

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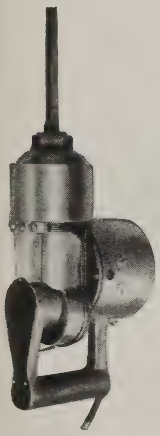

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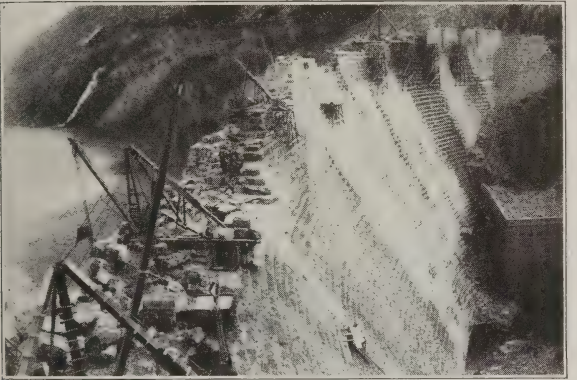

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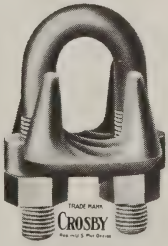

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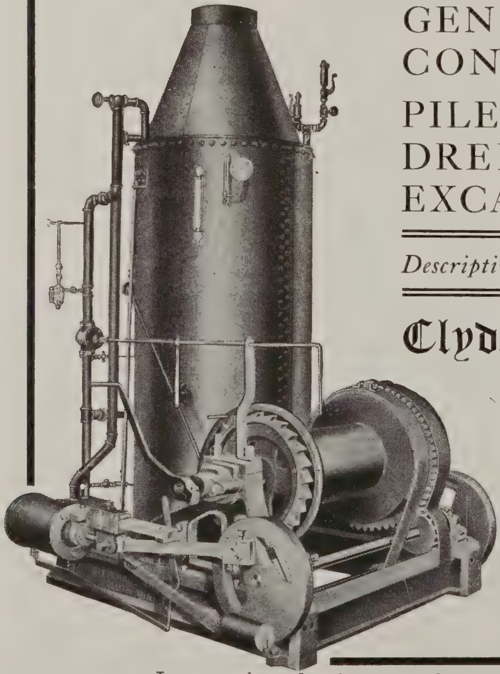

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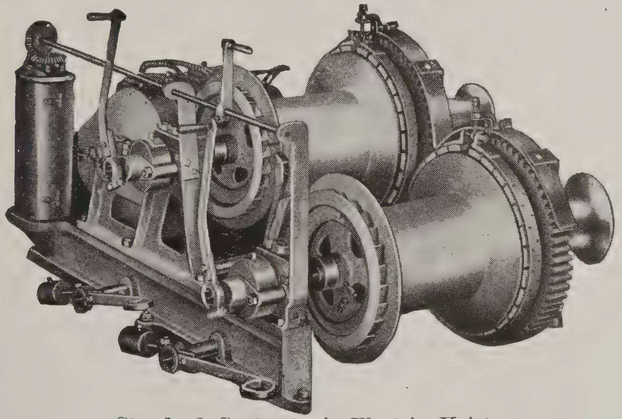

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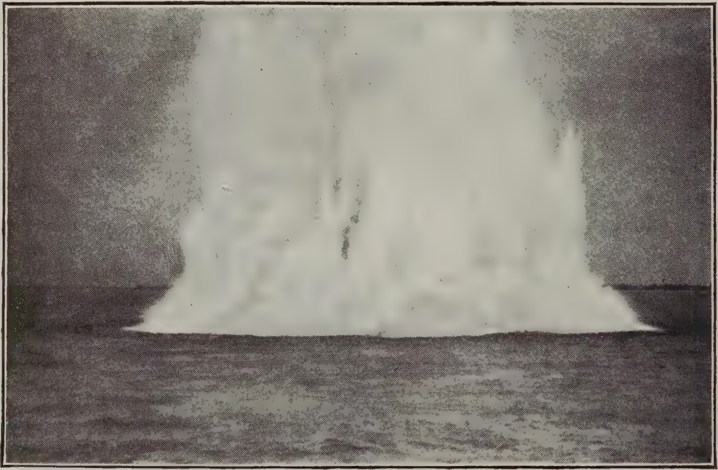

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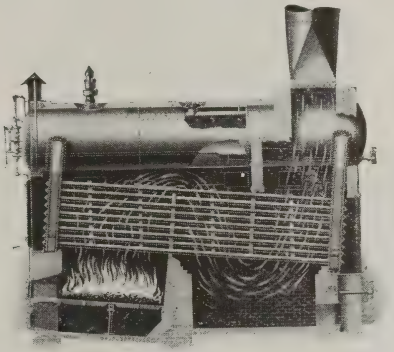

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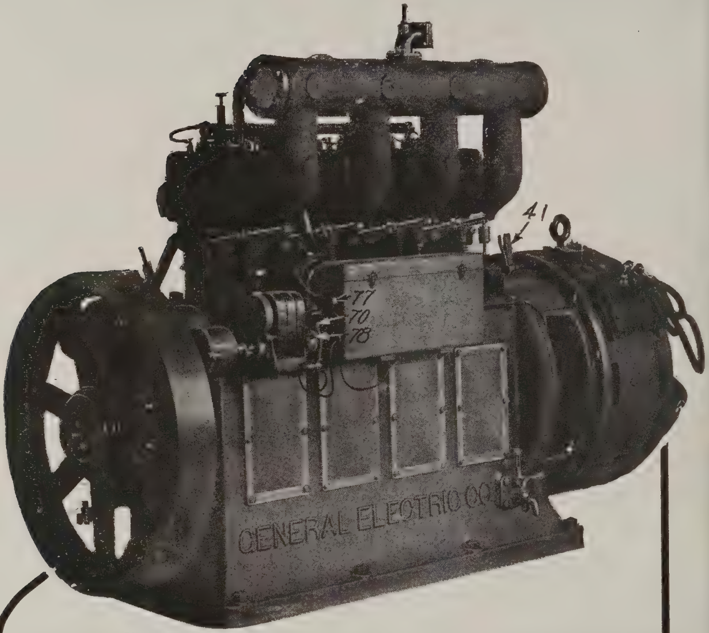

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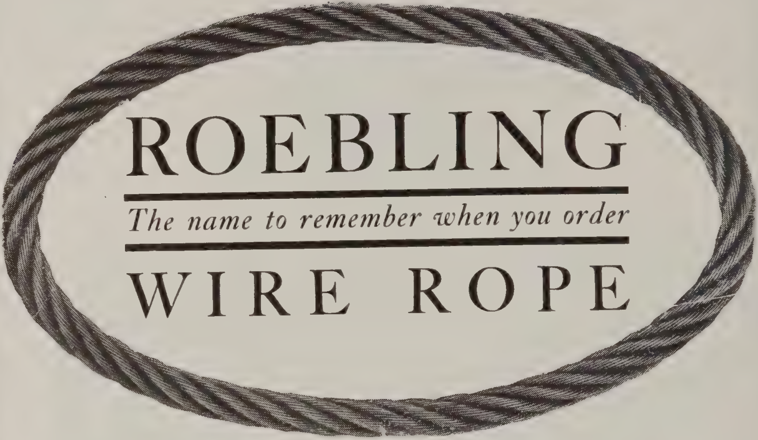

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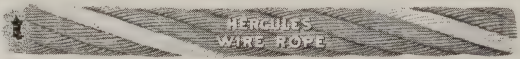

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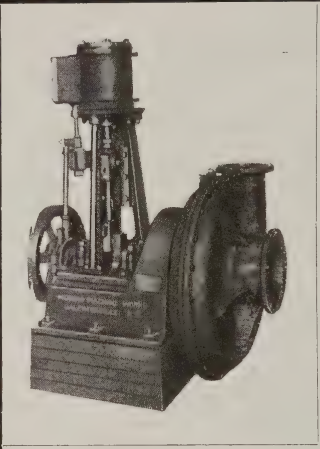

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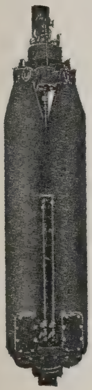

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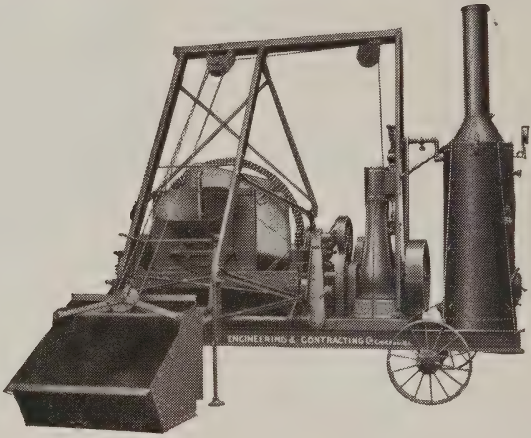

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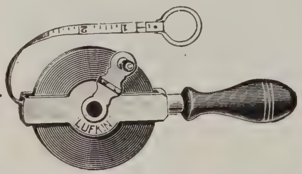

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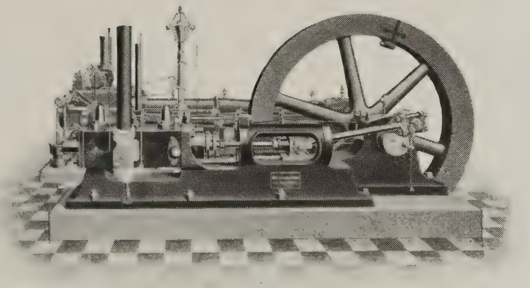

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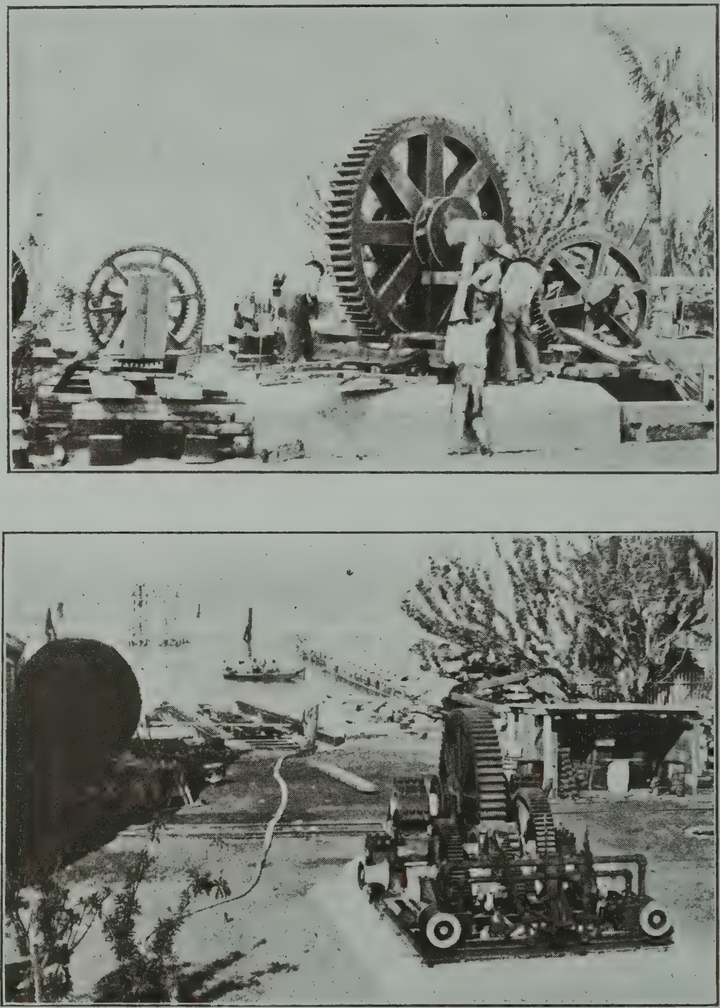

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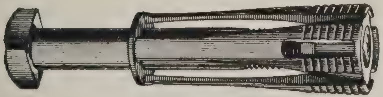

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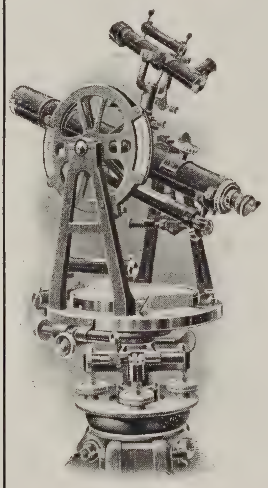

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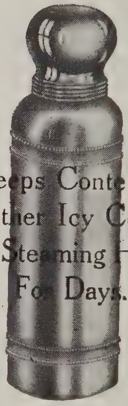

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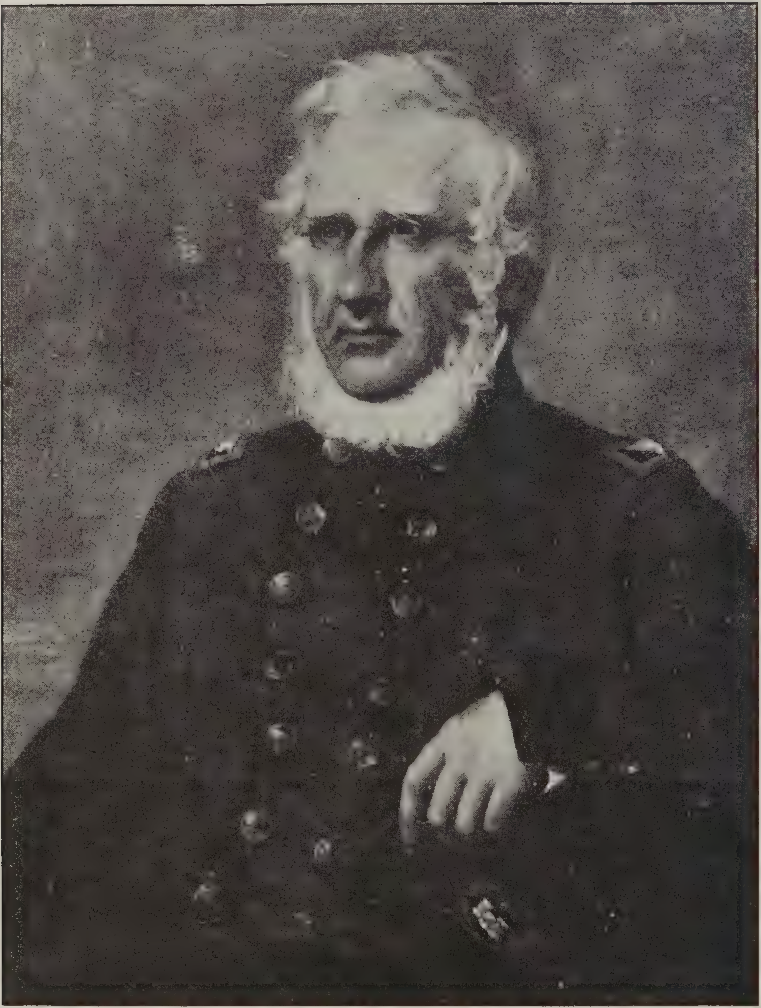

BRIG. GEN. RICHARD DELAFIELD
CHIEF OF ENGINEERS, UNITED STATES ARMY
1864-1866
BORN 1798—DIED 1873

IMPROVEMENT OF ARANSAS PASS, TEXAS

BY

Maj. GEORGE P. HOWELL
Corps of Engineers

The history of the improvement of Aransas Pass is typical of the vicissitudes encountered and the length of time taken in improving the harbors on the Texas coast. It is especially interesting, as the improvement has been undertaken in turn by private parties and by the general Government; and because it formed the battle ground for a contest between the Government engineers and the engineers for a private party endeavoring to improve the Pass. Although the first work of improvement was in 1868, at this date, 1911, the project is not yet completed and reports are still being submitted by boards of engineers.

Aransas Pass is one of the openings or inlets from the Gulf of Mexico through the chain of islands along the coast into the shallow waters behind them. It is 170 miles southwest of Galveston and 125 miles north of the mouth of the Rio Grande. Formerly, that is, in the seventies, almost all these passes or openings were being improved by the Engineer Department. Railroads in Texas were few and there were none paralleling the coast; consequently, transportation by water had to be used and advantage taken of every waterway, especially along the coast. At Aransas Pass there were regular schooner lines to New York and other eastern ports. Most of the commerce for northern Mexico came through this pass en route to Corpus Christi, whence it was taken overland. At that time there were no railroads west of San Antonio. In the past forty years great changes have taken place, owing to the spread of the railroad system and increased size and draft of vessels. It is necessary that conditions in those days should be understood, in order to arrive at a just appreciation of the engineering methods employed by these pioneers. Otherwise, we will be inclined to laugh at these attempts which seem so futile at this day. River and harbor work did not amount to much in those days. The great projects that have

opened the harbors of the country to the deep-draft vessels and have added to the fame of the Corps of Engineers had not been undertaken. The report of the Chief of Engineers for 1874 shows that 46 officers of the Corps of Engineers were engaged on river and harbor work, of whom only 15 were exclusively on this work. One officer, Capt. C. W. Howell, had charge of all the work on the coast west of and including the mouth of the Mississippi River. The River and Harbor Bill was small in amount, as the country was just recovering from the effects of a great war. No system of continuing contracts had been evolved. It was not known when a bill would be passed and the small driblets handed around would have shocked the executives and chairmen of river and harbor committees of these days. It seems to have been the general custom for the bill to fail and all work would consequently be suspended. The next appropriation for an improvement would be small, $25,000 or $50,000, which would get the plant in working order and very little more.

The aim was to open the passes so that boats of from 8 to 12 feet draft could use them. There were no railways, and so the material used in construction had to be of local origin. Also, when the project was formed and the estimated cost was found to be as much as $700,000 or thereabouts, the officer would know that it would be foolish to send in such a report, and that even if it were adopted the money would not be forthcoming. For instance, in 1874 an estimate was submitted for the Galveston jetties of $1,250,000. Appropriations were made as follows: 1875, $150,000; 1876, $142,000; 1878, $125,000; 1879, $100,000; and so on. The officer in charge of an improvement had therefore to cut his coat to fit the cloth and endeavor to work with material found in the vicinity, and with the knowledge that the work had to be done cheaply.

A brief glance at the projects of the Texas harbors will show how the attempt was made to solve the difficulties. It might as well be said that all of them failed. At Galveston parallel jetties were to be constructed by means of structures called gabions, 6 feet in diameter and 6 feet high, woven of brush, fitted with wooden covers as well as bottoms and plastered over with cement. They were to be placed in two rows to form the jetty and were to be filled with sand through a hole in the cover from a dredge alongside as they were placed in position. It was thought that the jetties would catch the drifting sand until they were covered, and that

afterward the sand would be carried over them rather than around their ends. They would be submerged jetties, since, ordinarily, the tops of the gabions would be 5 or 6 feet below mean low tide.

At the mouth of the Brazos River, the next opening below Galveston, two converging jetties of closely driven palmetto piles were to be used. At Pass Cavallo the project was first made for gabion structures, but when work began, in 1880, the jetties were built of brush mattresses and concrete blocks. At Aransas Pass, as will be shown later, brush mattresses and stone were used; and at Brazos Santiago, the last entrance, brush mattresses weighted down with bricks made in the vicinity of the Pass, weighing about 15 pounds each. It was probably just as well that Congress was not liberal with its money. Nevertheless, considerable money was spent and wasted. At Galveston, on the gabions $620,000 was spent; at Pass Cavallo, $290,000; at Aransas Pass, on the first mattress jetty and subsidiary works, $390,000; at Brazos Santiago, $257,000. No increase in depth was obtained.

EARLY ATTEMPTS AT IMPROVEMENT

The harbors on the Texas coast all have characteristic features in common. A sand cordon thrown up by the waves and littoral currents, at most points, extends along the whole shore, often forming a series of lagoons between itself and the mainland. The Texas rivers are small and, at times of low water, have too insufficient discharge to scour outlets into the Gulf. The lagoons, which are shallow and often inter-connected, cover extensive areas, but as the tidal oscillation which supplies the only constant power available for deepening the pass through the cordon, is only about 1 foot in height, the volume of tidal flow is, ordinarily, small, and the currents weak. When, however, long-continued southeasterly winds have raised the water level behind the cordon several feet, a sudden ''norther'' will force out an immense volume and in so short a time as to generate a current destructive to ordinary contraction works.

Aransas Pass is the outlet of Aransas Bay to the Gulf of Mexico. The area of the bay is about 80 square miles. It is connected to the southward with Corpus Christi Bay and to the northward with other shallow bays. The total area of these bays amounts to 350 square miles. The ordinary tidal range is about 1.1 feet, but at times of storms it is about five or six times as great. Aransas Pass lies between St. Joseph Island on the north and

Mustang Island on the south. Opposite the Pass lies Harbor Island, which is low and easily overflowed. It is formed chiefly of mud and is therefore more permanent than the sand islands. Between Harbor Island and St. Joseph Island is a deep channel which constitutes the harbor. Rockport, on Aransas Bay, lies about 12 miles to the northward, and at the head of Corpus Christi Bay is the city of Corpus Christi. A new town of Aransas Pass lies 7 miles from the pass across Harbor Island. These places are all on the San Antonio & Aransas Pass Railroad. Corpus Christi is also the terminus of the Mexican National Railway and the St. Louis, Brownsville & Mexico Railroad uses the latter's track to get into Corpus Christi.

The obstruction to navigation is the sand bar outside of the gorge, over which, between 1851 and 1890, the coast survey charts show a depth of 9 feet. Capt. George B. McClellan, Corps of Engineers, U. S. A., examining the locality in 1853, reported that the bar was composed of loose shifting sand exposed to change of position after heavy storms, causing a swash channel near St. Joseph Island and a deeper channel nearer Mustang Island, to which position the channel constantly tended to shift. He stated that if the improvement of the Pass by jetties was attempted, the effect would be to prolong the walls of the outlet to the present position of the bar and a new bar would form on the outside. The new outlet would be liable to be closed by storms, like the inlets on the Florida coast. In 1869, the first work of improvement was undertaken and it was done by private parties, $10,000 having been subscribed by citizens of Rockport. A jetty 600 feet long was constructed from St. Joseph Island, ½ mile from the channel, to cut off a secondary channel. (Fig. 1.) It was built of parallel rows of triangular cribs filled with brush and stone and it was expected to catch sand and throw the water into the main channel. Shortly after the jetty was constructed, this secondary channel shoaled about 2 feet and the main channel increased in depth by 2 feet, but pilots said it was due to storms. In 1871 there was no trace of the jetty.

The first plan of improvement of the Pass was made in 1879 by Captain Howell, the district officer. He recommended building a single jetty from St. Joseph Island, revetting the head of Mustang Island, and planting with trees the lower end of St. Joseph Island to prevent that island from losing sand by wind drifts. The cost was estimated at $140,000. He also recommended the closing of Corpus Christi Pass, the outlet to the Gulf at the lower end of

Mustang Island, 20 miles away. It was believed that the closing of this Pass was a necessary adjunct to the improvement of Aransas Pass. The head of Mustang Island had been wearing away and the Pass had been following it. The movement from 1868 to 1878 amounted to an average of 260 feet a year. The old charts show that the light-house is about opposite the channel of 1853; it is now 6,000 feet north of the Pass.

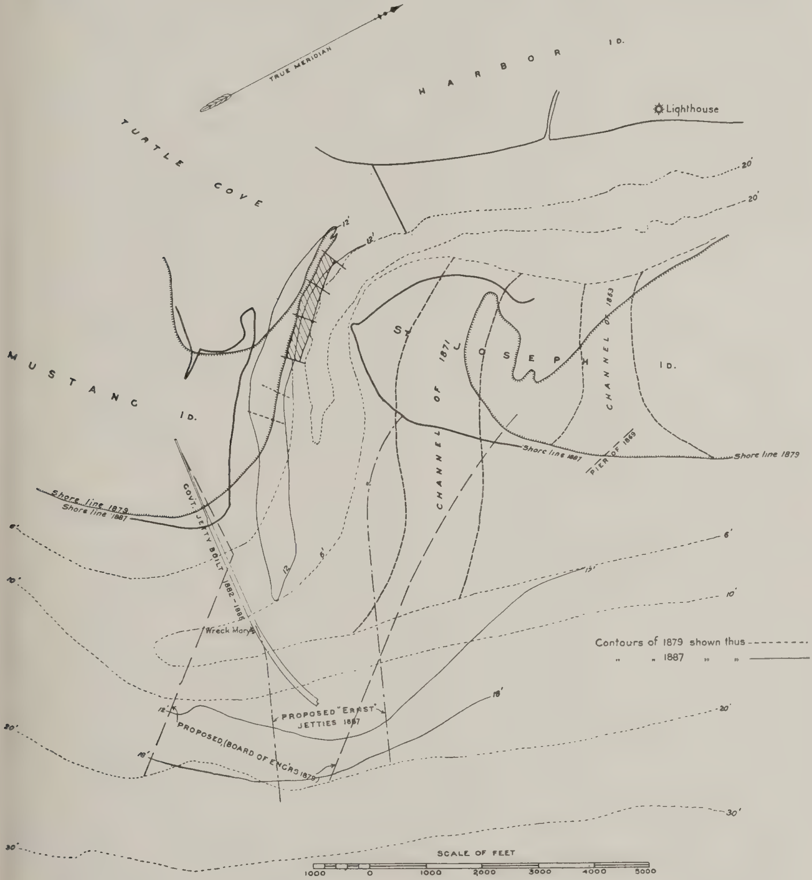

Fig. 1. Aransas Pass; Improvements Projected and Constructed to 1887

The plan of Captain Howell was reviewed by a board, consisting of Colonels Tower and Newton and Lieutenant-Colonel Gillmore. The board was in favor of two jetties, carried out to the 18-foot contour to afford a 12-foot channel, with groins and a flooring of mattresses to protect Mustang Island, at a cost of $759,185. (Fig.

1.) Colonel Newton proposed to dispense with the jetty from St. Joseph Island, retaining that from Mustang Island. He feared that the mere extension of the Pass by jetties might induce the closing of the channel, as by the consolidation of the drift sand about the jetties on both sides of the channel, the impediments to the water flowing in and out might be further increased and the closing of the Pass, if such tendency existed, accelerated. One jetty on the south side of the Pass might also suffice in connection with the north shoal to sustain the ebb currents. A wider opening would be left for the flood tide; and, finally, one jetty would be less costly than the two, and the other jetty, if from further experience it was considered necessary, could afterwards be constructed. The cost of this plan was $430,980. The single jetty idea was used by the engineers of the private company later, but as will be seen, it was placed on the opposite side of the channel. The jetties were to be constructed with a foundation of reed mats which were supposed to be teredo proof, weighted with small stone, and the upper and exposed surfaces paved with large stone or concrete blocks. Brush might be placed in the interior of the work where it was not exposed to the worm.

Work was carried on under this single jetty plan between 1880 and 1885. The jetty was constructed from Mustang Island on an east and west line to a point 2,352 feet from shore, near the wreck of the Morgan line steamer *Mary,* in 1876, where it curved to the north for a distance of 1,698 feet, the total length in water being 4,050 feet. It extended inward to the sand hills, a distance of 1,321 feet. (Fig. 1.) It was built to about 3 feet above mean low tide and about 12 feet above the bottom. This jetty was subsequently known as the old Government jetty, or the Mansfield Jetty, to distinguish it from jetties subsequently built in this locality, Major Mansfield being the officer in charge at the time the jetty was built. A storm in 1885 carried away the top works of the jetty and otherwise damaged it. The channel at the beginning of the work was to the east of the jetty,but it had swung to the south and crossed the outer end of the submerged jetty at a point 425 feet from its end. An examination in 1887 showed that the curved portion had disappeared and that the top of the straight portion was about 3 feet below mean low water. The money spent on this jetty amounted to $393,556.95, including $10,000 contributed by the citizens of Rockport and Corpus Christi in 1883, when it was

seen that the work would cease owing to lack of appropriations by the Government.

To protect Mustang Island from wearing away, a revetment had been constructed as follows: A breakwater had been constructed across the northwest end of the island and from this as a base seven groins had been run out. The work was composed of mattresses ballasted with very soft stone and natural concrete mixture of shell and sand. At the shore the crests of the jetty were at the water surface, and at the outer end they were from 5 to 15 feet below. In 1887, these works were about all gone. The brush had been eaten by the teredo and the revetment, built on dry land, was about 100 feet from shore and, though the rate of erosion had been held to about 70 feet per year, no further reliance could be placed on the revetment.

The curved jetty had been found open to numerous objections. Its action was uncertain and irregular. Being designed to stand in the way of water flowing at various velocities, it is difficult to determine what degree of curvature will obstruct the flow enough to excavate a channel without undermining the work. If adapted to one velocity it would not answer for another velocity. There would be excessive scouring and undermining at storms and no action at average tides. It is costly to build, difficult to maintain, and badly adapted to future extensions. An extension of 2,000 feet at Aransas Pass would bring it across the channel parallel to the shore. It can not be used with twin jetties.

A revision of the plan was made in 1887 by Major Ernst, the district officer. Comparing the various surveys, he found that the distances between the corresponding contours inside and outside the bar had remained about the same; and that the surface width at the gorge between St. Joseph and Mustang islands had varied from 2,810 feet in 1868 to 1,785 feet in 1887. From a comparison of the maximum depth, surface width, and area of the gorge cross section at various times, Major Ernst showed that if the width had been reduced to 2,000 feet (corresponding to a maximum depth of 30 feet) without any increase in depth, the reduction in area would have been less than 8 per cent; that is, the velocity would have been increased at about that ratio. Hence, considering the leakage through the jetties there would be no undue contraction if they were placed 2,000 feet apart. A greater distance would fail to develop the full capacity of the entrance. The gorge being sheltered from the Gulf waves, it was not to be expected that the

full dimensions of the gorge could be carried out to deep water and maintained. If the width were preserved, the depth would be decreased. With a width between the jetties of 2,000 feet it was reasonable to expect a depth of 20 feet. The plan proposed by Major Ernst was to abandon the curved portion of the jetty already constructed and to carry it by the shortest line to the deep water; and to construct from St. Joseph Island a north jetty parallel to the existing jetty and 2,000 feet away from it. Both jetties were to be extended to the 20-foot contour; to be 12 feet wide on top at the inner end and 24 feet at the outer end; to be 5 feet above mean low water and to be entirely constructed of stone, the foundations being simply a broad base of ordinary riprap. (Fig. 1.)

The head of Mustang Island was to be revetted by covering the slope from high water to the bottom of the channel with a continuous riprap revetment, 18 inches thick; the width of the revetment to be 200 feet and the length about 2,500 feet. The cost of these two works was estimated at $1,668,500. With the funds available work was carried on between 1888 and 1889 on the revetment only, nothing being done on the jetties. The money spent on the revetment was $156,859.65. (Fig. 2.) It prevented any further erosion of Mustang Island.

IMPROVEMENT ON THE PLANS OF PRIVATE PARTIES

A board of engineer officers having been appointed in 1889 to select a deep water harbor on the northwest coast of the Gulf of Mexico, recommended Galveston, but commended Aransas Pass as worthy of great consideration. In view of the smallness of the appropriations by Congress for Aransas Pass and the belief among the citizens that any money hereafter appropriated would be for the benefit of Galveston, Congress, on May 12, 1890, granted certain rights to the Aransas Pass Harbor Co., a private concern, and the Government relinquished charge of the work. Many companies had previously been formed, under the laws of the State of Texas, to form channels within the bays and to improve the passes, etc., but no work had actually been done in this vicinity except by the Port Aransas or Port Ropes Co., in 1889 and 1890, their endeavors being to form a channel across Mustang Island 10 or 12 miles south of Aransas Pass, where the island is about 10,000 feet wide. The depth of water in the channel was to be 30 feet; what work was done lasted only a short time.

The Aransas Pass Harbor Co. was organized under the laws of the State of Texas, March 22, 1890, for the purpose of constructing necessary wharves, docks, etc. Congress, in 1890, gave this company the right to build and own such constructions as would be necessary for improving Aransas Pass to give a 20-foot channel. The State of Texas granted the company the right to buy land at $2.00 per acre on Harbor Island and Mustang Island, provided the company secured 20 feet depth by 1899. The earlier plans of im-

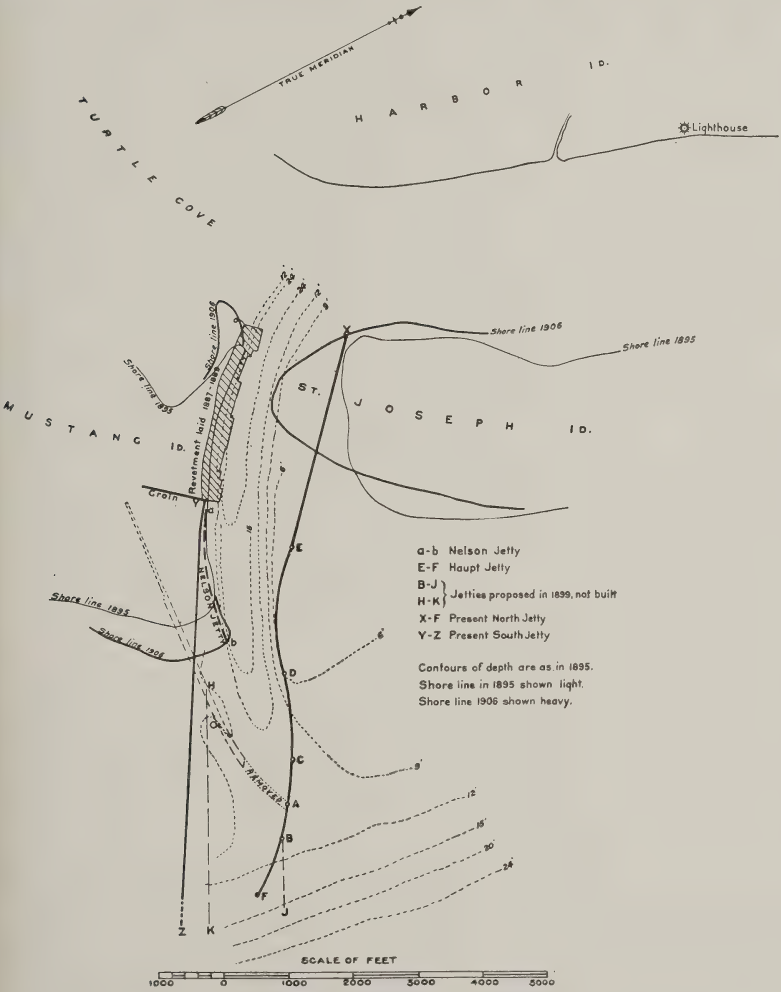

Fig. 2. Aransas Pass; Improvements after 1887

provement had called for a 12-foot channel, which was sufficient in the pre-railroad days for the light-draft coasting vessels; but, since 1886, conditions had changed,for in that year the San Antonio and Aransas Pass Railroad had been completed, this line being the shortest to the coast for a large portion of western Texas. This road extended both to Corpus Christi and to Rockport and was preparing to locate a terminal on Harbor Island, which lies just opposite the Pass. The natural harbor for ships entering the Pass lies between Harbor Island and St. Joseph Island. In 1887 it had a depth of 18 feet and width of 400 feet for a length of 2 miles, and for half the length the depth was over 20 feet. With a railroad headed for this harbor, it was natural to expect that it would be used by ocean-going vessels and that the depth of the channel across the bar should be increased to 20 feet.

The first work done by the company was the construction of a jetty, called the South or Nelson Jetty (from the name of the engineer), in 1892. It started from Mustang Island and extended on a curve concave to the channel for a distance of 1,800 feet. It was about 700 feet to the westward of the old Government jetty, lying approximately parallel to it. (Fig. 2.) It consisted of a row of cylindrical wooden caissons, 7 feet in diameter, filled with sand and stone and riprapped, especially on the western side, as a protection against the scour caused by the water falling over the jetty at flood tide.

The construction of this jetty exhausted the funds on hand and when the work was next resumed it was upon an entirely new plan. Two civil engineers had been retained as consulting engineers, Prof. Lewis M. Haupt and Mr. H. C. Ripley. The plan adopted on the advice of these engineers was the construction of a single jetty, which is thus described by the designers:

> This structure consists of a line of works detached from the shore, every portion of which has its special function to perform, and which is intended to utilize and cooperate with the work which has already been done. The outer concavity is constructed on a curve whose radius is that which now produces and maintains depths of from 30 to 40 feet when protected from wave action and littoral drift, as in the concavity inside of the Pass; the middle or convex curve is designed to concentrate the ebb currents and increase their surface slope over the bar, while its opposite concave face will collect sand and reinforce that portion of the work; the salient is intended to divide the flood currents during the first quarter and aid the discharge of the later ebb currents, while the funnel formed by the breakwater and the shore of St. Joseph Island will aid the influx

of flood tide and increase the efflux passing out over the lower portion of the bar, thus changing the condition of equilibrium in favor of ebb scour.

However, the form of jetty was modified before work began, and the actual structure built is described as follows:

> In plan it will differ from the usual form of jetty or breakwater, being detached from the shore and located on the bar to the "windward" of the channel. Its axis will be curved (compound and reverse), to produce reactions similar to those found in the concavities of streams, and having radii sufficient to maintain channels of the requisite depths, as revealed by existing curves and their resulting depths of over 30 feet, now found inside the bar. It is designed to fulfill the fundamental conditions of (a) arresting the littoral drift; (b) admitting the full tidal prism to the interior lagoons; (c) controlling the ebb currents and producing a reaction across the bar; (d) changing the conditions of equilibrium of flood and ebb currents in favor of the latter, and (e) of affording aids to navigation by a structure of only half the length of the usual convergent or parallel jetties in pairs.
>
> The work will be executed in two parts. The first will consist of 1,250 feet of completed breakwater and 2,500 feet of foundation extension. The second of 5,950 feet of completed breakwater and 250 feet of foundation extension. It is to be covered with a substantial apron of heavy blocks, weighing from 2 to 5 tons, carefully placed so as to produce a permanent and substantial structure.
>
> The construction of the proposed breakwater as designed will unquestionably result in securing navigable depths over the bar of 15 feet for the first part of the work and 20 feet for the second.
>
> The development of these depths will commence immediately upon the construction of the foundation course, which will be greatly hastened by the strong currents resulting from the "northers," and which occur between September and March. If a more rapid development of depths is desired than will result from natural causes, deepening may be facilitated by dredging or other auxiliary appliances.
>
> Since the forces necessary to maintain a channel are much less than those required to create it, a channel once developed and protected from silt, as this will be, may be maintained by the natural tidal currents from the bays; hence the cost of maintenance under the plan proposed would be a minimum.

This jetty, called the North or Haupt jetty, was built between August, 1895, and September, 1896. It was to start about 1,500 feet out from St. Joseph Island, and follow seaward the general direction of the Pass, on a curve 2,000 feet in length and with a radius of 3,000 feet, convex toward the channel side; then a reverse curve 2,200 feet long with a radius of 6,000 feet, compounded

with a curve 2,000 feet long, with a radius of 4,000 feet. This compounded curve is concave toward the channel. The depths on the line of the jetty were, at the beginning of the work, generally from 9 to 11 feet, with an extreme depth of 17½ feet at the outer end and shoaling at the inner end to 5 or 6 feet. The estimate of the contractor to build this jetty was $285,000.

The harbor company decided not to build the jetty complete at once, but to build a certain definite portion. It was stated by the consulting engineers that the construction of this definite portion would unquestionably secure navigable depths over the bar of 15 feet. A contract was entered into with a firm in Galveston for $145,000 for the following work (Fig. 2): Starting from a point F on the 15-foot curve, about 450 feet inside the outer end of the jetty as designed, and building first 1,000 feet of foundation from F to B; then 1,250 feet completed breakwater B to C; then 1,500 feet of foundation C to D; total length, 3,750 feet, ending at a point where the reverse curve begins, 2,000 feet inside of inner end as designed. This work was begun July 24, 1895, and completed July 22, 1896. The jetty was constructed by laying fascine mattresses 100 feet long and from 40 to 50 feet wide, and spreading over this the rock foundation 3 feet thick and 50 feet wide for 1,750 feet from the inner end and 60 feet wide for the remaining 2,000 feet. The stone was a sand stone of good quality, average weight, 142½ pounds per cubic foot, and of sizes from 100 to 1,000 pounds, filled in with quarry refuse. On this foundation was placed, from B to C, 1,250 feet, a core, built up to low water, of similar stone covered with cap and face stone weighing from 2 to 10 tons, so as to give a top width of 10 feet and slopes of 1½ and 2 horizontal to 1 vertical.

The 15-foot depth expected was not obtained by this jetty and the company decided to extend the work. Additional work was done in the early part of 1896 in accordance with which the jetty was brought to the state of completion, in which it was turned over to the Government. The foundation was laid from outer end F to inner end E, a distance of 5,750 feet, with widths varying from 60 to 25 feet. When the inner end was laid, there was but 3 or 4 feet depth of water at that point. On this foundation from B (a point 1,000 feet within F) to C, 1,250 feet, the jetty was built complete; thence to D, 1,500 feet, the core was put in and the capping partially placed; thence to E, 2,000 feet, a portion of the core

was laid. This jetty failed to give any considerable permanent increase in depth.

In 1896, a contract was made whereby the contractor was required to obtain within eighteen months and maintain for a year a channel not less than 150 feet wide on bottom and not less than 20 feet deep at mean low tide, for the full width of the channel. The contract stated that a dredged or blasted channel would not be in compliance with the terms, but that the contractor should complete the present uncompleted breakwater in such a manner as to make it effective to maintain a channel, and build such other spurs, jetties, and breakwaters as might be necessary to secure and maintain the channel. The original project of a single jetty was apparently thus given up. The harbor company agreed to pay the contractor the sum of $500,000. The contractor, by working to the extent of $15,000, blasted the channel with dynamite and placed sand bags near the Nelson Jetty to accumulate sand. A large portion of the dynamite was used to blow out about 500 feet in length of the old Government jetty which crossed the channel at an angle of 45 degrees with depths of from 8 to 14 feet, and was considered as presenting an obstruction to further deepening. The contract was subsequently annulled.

By direction of Congress, in 1897, a board of officers was appointed to ascertain the character and the value of the improvements made at Aransas Pass. The board reported that the total amount expended by the Government prior to 1890, when the work was turned over to the harbor company, was $550,416.58, and the value of the improvements as turned over was: old jetty from the shore to the wreck *Mary*, this portion being covered with sand and supposed to be in good condition, $68,400; the revetment on Mustang Island, $163,207; a total of $231,607; that the South, or Nelson, Jetty, constructed by the company, had been greatly damaged by storms and teredos and was in a very dilapidated condition; that the North Jetty had never been completed as designed; that the depth that could be carried over the bar had not been materially, if at all, increased by the works constructed by the harbor company. A chart of October, 1895, showed an irregular line over the bar of about 13 feet depth and one of February, 1896, 10 to 11 feet. At the time of the examination by the board, in 1897, the depth was 8.8 feet. The position of the channel had become more constant and the width across the bar had lessened; the distance between the 20-foot contours being, in 1875, 5,500 feet, and in 1897 4,200 feet.

This lessening in distance had been caused by the advance of the inner contours, the outside slope having changed but little.

On some of the charts a deep narrow trench running alongside of the jetty was shown, but this trench could not be used by vessels. The channel used by the pilots at that time passed directly over the North Jetty a few hundred feet within the outside end. The board reported that there did not seem to be any probability that the jetty would of itself secure and maintain any considerable increase of depth in a navigable channel of proper width, and stated that in its opinion the original plan of parallel jetties was the proper method of improving the Pass; that such jetties would run approximately at right angles to the bar and allow of future extensions; that they protected the channel from sand drifting into it from either side, and vessels coming in between them were to a great extent protected from cross currents and waves while required to keep in a comparatively narrow channel; that it was comparatively easy to obtain and keep open a deep channel by occasional dredging; and that the entrance could be kept at a width sufficient to provide for a free admission of the flood tide, without diminishing the available space for light-draft sailing vessels.

The Aransas Pass Harbor Co. had adopted a plan in conflict with the Government's and prosecuted with vigor the portion of it which the engineers stated would produce 15 feet of water, completing it in six months. As expected, results were not obtained; they did some 50 per cent more work without getting the 15 feet. After having done about three-fourths of the work necessary, according to the engineers, to get 20 feet, and at least 50 per cent more than was required to obtain 15 feet, without securing any direct or permanent improvement, the company appeared to have lost faith in their own plans, as they then made a contract to secure a 20-foot channel at a price fully 60 per cent greater than the entire original cost of their reversed curved breakwater, as bid on by the contractor. This contract was soon abandoned. The board was of the opinion that in the future improvement of the Pass it would be impossible to include the existing constructions, since the North Jetty was so located as to prevent carrying out the Government project of improvement, except by removing the jetty as it diagonally crossed the space between the proposed jetties. This removal would be very costly and it would probably be advisable to take up only the outer portion and leave the remainder as a part of the northern jetty in connection with a southern one. The

width between these jetties would be less than one-half of the width proposed by Major Ernst, and therefore the opening between the North Jetty and St. Joseph Island might have to be left to prevent cutting off the tidal inflow.

The board stated that while the improvement of the Pass had been greatly complicated by the work constructed by the harbor company, and the Pass would never be as good as it would have been had this work never been constructed, a plan could be devised that would give, for a reasonable cost, a good navigable channel of 20 feet depth with the aid of inexpensive dredging. The board therefore decided that the value to the Government of the works of the Aransas Pass Harbor Company by the improvement of the Pass was nothing.

By the act of Congress, March 27, 1899, the Aransas Pass Harbor Company surrendered its rights and the United States Government again took control. The board of officers was reconvened to submit a plan for the improvement. It reported in favor of obtaining a navigable channel 20 feet deep and 150 feet wide by building two parallel jetties, the North Jetty to be in the line of the jetty constructed by the Aransas Pass Harbor Co. and the South Jetty to be 1,200 feet away. (Fig. 2.) The board would have preferred a more northerly location of the sea end of the jetties and a greater distance apart, in accordance with the Ernst plan, as the distance to deep water would have been less, but the difficulty of removing the jetty so as not to interfere with a suction dredge would prevent this plan from being carried out. A portion of the old Government jetty and the outer 1,000 feet of the foundation of the Haupt Jetty would have to be removed in any case. The jetties were to extend to the 20-foot curve and the inner end of the Haupt Jetty was to be connected with St. Joseph Island by a rock sill, 3 feet thick and 40 feet wide. The cost was estimated at $1,525,000, including the removing of a portion of the Government and Haupt jetties.

This plan was not immediately adopted by Congress. The designers of the curved jetty had sufficient influence to get Congress to continue experimenting with it, although the Corps of Engineers had never favored it. The work at Aransas Pass was confined by acts of Congress of 1902 and 1905 to the completion of the North Jetty in accordance with the designs and specifications of the Aransas Pass Harbor Co. and to such additional work as should be necessary for strengthening the jetty and removing obstructions in

the channel. The work was completed in accordance with these specifications, in 1906, at a cost to the Government of $546,703.10. The jetty was rebuilt for its entire length of 5,750 feet, or from Station 20 (''E'') to Station 77+50 (''F''),* according to designs furnished by the harbor company. (Fig. 3.) The small riprap was to be in pieces weighing from 10 pounds to 2 tons, and the large riprap in pieces not less than 2 tons in weight and averaging 4 tons. The crest blocks were to be granite, as closely rectangular in form as practicable and varying not over 6 inches from the dimensions, 3½ by 5 by 8 feet. The top was to be 4 feet above mean low water. Besides the jetty construction, the outer 1,000 feet of the old Government Jetty was removed, leaving a clear waterway of 800 feet between it and the North Jetty.

As to the effect upon the channel, a survey of 1900 showed along the south side of the jetty a deep trench from 18 to 25 feet deep threatening to undermine the jetty, and on the north side of the jetty a similar trench for a distance of 800 feet from the outer end. The navigable depth across the bar was 15½ feet. In 1902 there was a narrow and crooked channel close to the jetty with minimum depth of 14½ feet, although, on account of the narrowness, it could not be used by vessels with a greater draft than 10 feet. The channel showed a tendency to sweep seaward in an easterly direction at D and at B (Fig. 4), caused by the shoal forming from the south of Mustang Island, near the wreck of the *Mary*, during the summer months. In 1907, the year after the final work was completed, there was a very narrow channel along the jetty with 16.3 feet minimum depth, but for navigation purposes the depth was only 12 feet.

The single curved jetty had proved a failure. There are three main points about this jetty in which it differed from the Government jetties—the side of the channel on which it is located, its curvilinear form, and the gap at the shore end. In planning jetties, the jetty on the side from which comes the resultant sand drift is the more important. This has been called the ''windward jetty,'' the term being used not with reference to the wind, but to the resultant sand drift which is caused by the wind. It does not always appear easy to determine which is the ''windward'' side, since the harbor company's engineers stated that their jetty on the north side of the channel was on the ''windward'' side, while the Government engineers claimed the south side was the

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* See description of jetty on page 374.

"windward" side. It is important that the jetty should intercept the littoral drift. It has been stated* that the Pass had been moving to the south, the foot of St. Joseph Island following the movement and the north end of Mustang Island being washed away. It would seem therefore that the resultant drift must be to the south, and the jetty was placed on the north side of the channel. The testimony of the Government engineers who have been at work at the Pass is to the effect that during the greater part of the year the current runs to the north, the effect of the prevailing south winds. A diagram of the wind at Corpus Christi, 20 miles away, shows a remarkable predominance, both in time and strength, of the winds from the southeast. The effective winds to produce movement down the coast are from the east and northeast, and these were insignificant in comparison with the southeast wind.

Why, then, should the inlet have moved to the south a long distance against the resultant drift? The shallow lagoons inside the sand cordon have usually only about 1 foot of tide once a day. There being so small a tide, the currents alongshore caused by it must be small also, and the only force left worthy of consideration as producing littoral drift is the wind acting through the waves and currents produced by it. But in times of "northers" the swollen waters in the lagoons are driven violently to the south, escaping to the Gulf through the inlets at the southern part of the bay, and eroding the south side of the inlet. This is the reason why Mustang Island has eroded. What was formerly the channel gradually shoals and St. Joseph Island has extended to the south by the sand driven inshore by wind and waves.

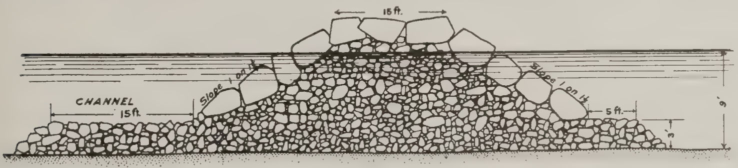

Fig. 3. Cross Section of Haupt Jetty, as Planned by its Designers and Constructed by the Government

The curvilinear form of the jetty was to produce reaction across the bar, based upon the idea of concavities in streams. The deepest water is found on the concave bank and the curved jetty was expected to produce the same results. A river, however, has a second bank, which holds the current against the curve. The cause

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*See page 367.

of the deep waters being found at the concave bank is generally accepted as due to the boring action of eddies, the axes of which are vertical, and which are caused by the friction of the swiftly running water against the bank. The sand thus put in motion by such a reaction along the jetty would apparently be carried to sea and deposited on the bar, the same as material carried by any kind of current. The designers of the reaction jetty, however, claimed that the eroded material would be transferred directly across the channel and deposited on the sand bar opposite, being led to this belief by the fact that in concavities in a stream the rush of water against the concavity banks it up above the normal level and causes a down draft at the bank and across the river in a helical direction. This action may occur in narrow crooked streams with rapid currents, but would be wholly out of place in a jetty on an ocean bar; it would require a very swift current toward the jetty to produce a head sufficient to cause the strong helical motion required to transport the material across a channel of navigable width, and such a rush of water would be dangerous to shipping.

The gap was left to admit the full tidal prism. As, according to design, the jetty was to be on the windward side, the gap would also admit the full littoral drift. A bar would be formed at this point which would push the channel away from the jetty, and no second jetty is provided on the opposite side to bring the current back and make it scour this sand away. Little sand did drift through this gap because the jetty was not located on the windward side. In the earlier designs of jetties by the Corps of Engineers, at Charleston, S. C., for example, gaps were left at the shore end: but such practice is now regarded as a mistake, since the sand thus washed in is scoured out by the ebb tide and deposited on the bar, causing additional dredging. The jetty should be well above high water at its inner end and generally it will have to be above high water for its entire length to prevent sand from coming over it and getting into the channel.

PRESENT IMPROVEMENT

The present project was adopted by the River and Harbor Act of March 3, 1907, in accordance with the plans submitted by Captain Jadwin, the district officer, in December, 1906. The Haupt Jetty had been built according to the plans of the designers. The original report of the designers had alluded to the desirability of dredging to hasten the deepening from natural causes, but Captain

Jadwin did not think the dredging would be of lasting benefit, as the sand moving up from the south was extremely aggressive and would tend to fill up the channel very rapidly. A second jetty was therefore essential on the south side. The engineer board of 1899 had contemplated a south jetty on the line of the old Government jetty to the wreck of the *Mary*, thence running in a direction generally parallel to the Haupt Jetty and terminating in 20 feet of water, about 800 feet south of the outer end of the Haupt Jetty; the outer 1,000 feet of foundation of this jetty was to be removed and a new outer end constructed parallel to the South Jetty and 1,200 feet from it. Captain Jadwin proposed to retain the Haupt Jetty as the new North Jetty and to construct a south jetty, starting from the shore at the place where the old Government jetty crossed it and running in a straight line to a point 1,250 feet from the outer end of the Haupt Jetty. The jetty was to extend inward to

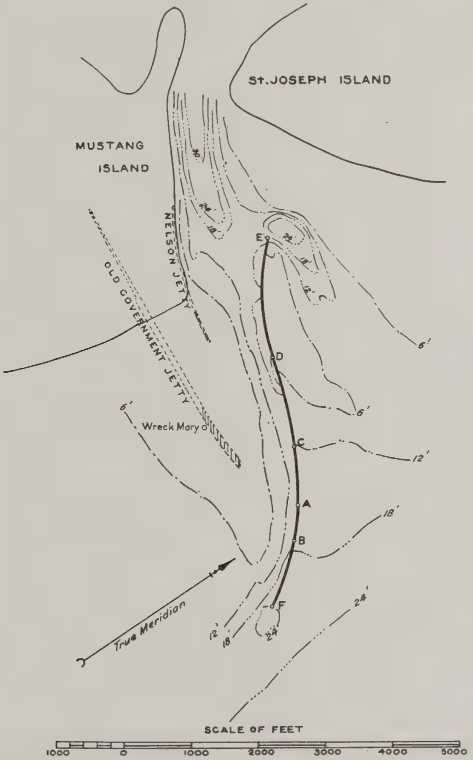


Fig. 4. Aransas Pass; Condition in January, 1908

the sand hills and be a total length of 6,000 feet. As the Haupt Jetty ended at the 20-foot contour in the Gulf, it was expected that with dredging a 20-foot channel could be obtained.

The plan also included the closing of the gap between the Haupt Jetty and St. Joseph Island, and the extension of the jetty across the island to prevent any cutting away of its lower end. The necessity for connecting the Haupt Jetty with the shore was shown by the fact that a dangerous hole had developed at the inner end of this jetty where the depths had been increased from 5 to 35 feet, showing that unless something was done promptly the channel would shift to this position. A secondary channel 600 feet wide and 6 feet deep did break through this gap, causing the channel for all practical purposes to be on the north side of the jetty instead of the south side. It eventually took 1,000 cars of stone to build the shore extension across this hole, a distance of 250 feet.

The estimated cost of the jetty work was about $500,000; and to build a dredge would require an additional $100,000, with $75,000 yearly for maintenance. It was contemplated that at a later date it would be necessary to extend both jetties about 1,750 feet, at a cost of $700,000, the North Jetty to terminate in 30 feet of water, in order to obtain a 25-foot channel. Later, however, in 1910, it was estimated that to obtain a 25-foot channel 300 feet wide by extending the jetties and dredging would cost over $2,000,000.

Work on the new project began on March 19, 1908, and is still in progress. The North Jetty has been extended across the gap to St. Joseph Island and across the island, making its total length 9,241 feet. The old Haupt Jetty portion of it has been repaired for about half its length, beginning at its inner end, raising it to a height of 5 feet above mean low tide. It had been built with too narrow a foundation and too steep side slopes, and as a result of undermining many of the crest blocks had been lost. The repairs consisted of strengthening the slopes on the channel side by large pieces of riprap and replacing the crest blocks. This work was done with a floating derrick. The South Jetty has been completed for a distance of 5,635 feet, and partially completed for a further distance of 865 feet, a total distance of 6,500 feet. A spur or groin 1,000 feet long has been built at the inshore end of the South Jetty at right angles to its direction and extended into the sand hills to prevent the cutting of a channel around the shore end of the jetty. It is intended to complete the South Jetty out to a distance of 6,500 feet, which is 500 feet longer than the original plan,

and to complete the repairing of the North Jetty. With this accomplished, the amount of money spent on the new project will be about $1,060,000, divided as follows: South Jetty, $610,000; shore branch North Jetty, $250,000; repairs North Jetty, $175,000; spur at end South Jetty, $25,000. The total cost of the North Jetty will then be $1,220,000, or $132 per linear foot; the cost of the South Jetty, $610,000, or $94 per linear foot. Deducting the $295,000 spent by the Aransas Pass Harbor Co., the cost of the North Jetty to the Government will be $100 per linear foot. It was not an economical proposition.

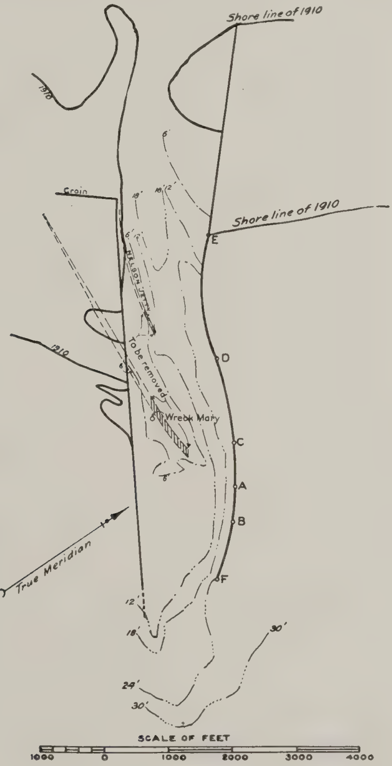


Fig. 5. Aransas Pass; Condition in July, 1910; Present 20-Foot Project

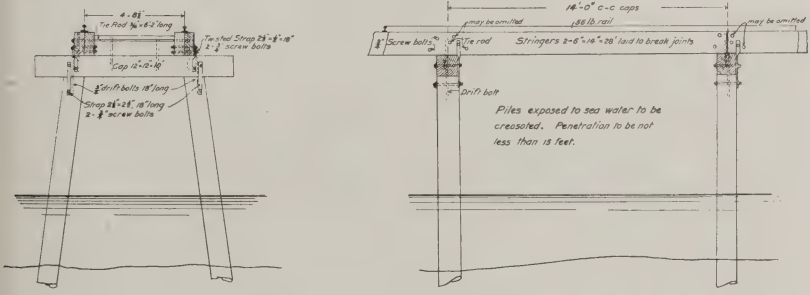
The adopted project now calls for a depth of water of 20 feet. Money has been appropriated for dredging and for removing from between the jetties the obstructions caused by the remains of the old Government and Nelson jetties and the wreck of the *Mary*. Work is now in progress on removing the obstructions, but no dredging

has as yet been done. The survey in July, 1910 (Fig. 5), showed a narrow channel 20 feet and more close to the North Jetty till it reached a point near the inner end where it crossed over to the Mustang Island side, the least depth on the crossing being 17 feet. Beyond there was a deep pool. The channel at the end of the jetty is very narrow, there being not over 250 feet distance between the jetty and the 12-foot contour, and it can be regarded as a practicable channel only for light-draft boats. By the completing of the South Jetty to its full height and removing the outer ends of the old jetties, especially the Government Jetty, which acts as a spur dike throwing the channel against the North Jetty, the entrance channel will assume a more central position between the jetties. This action will have to be supplemented by dredging to obtain a good straight channel.

Assuming that the project depth of 20 feet has been attained and vessels are using the entrance, an anchorage ground must be provided and a channel leading to wharves. At present the harbor facilities between Harbor Island and St. Joseph Island are very limited, and before the improvement of the Pass can be a success commercially an ample area must be provided where vessels can lie while waiting to be berthed or while in quarantine. It has just been recommended to Congress that a roadstead should be excavated 20 feet deep, 1,200 feet wide and 3,000 feet long, in front of Harbor Island, and that from the upper end of this roadstead a channel should be formed of similar depth, 400 feet wide, and 5,420 feet long, from which slips could be excavated into Harbor Island. It was also recommended that on the low southern end of St. Joseph Island a dike should be built of stone, 8 feet above mean low water, with a top width of 10 feet, extending down the middle of the island for a distance of 10,000 feet, to protect the roadstead and channel from drifting sand and secure the island from danger of erosion at times of high tides when there would be a tendency for the water to cut across the island and endanger the depth of water between the jetties. The cost of such a dike was estimated at $20 per foot, and the cost of the whole work $375,000. This project was adopted by Congress in its River and Harbor Act of February 27, 1911.

The method of construction is as follows: Owing to the shallow depth of water in which the South Jetty lies, varying from 0 to 12 feet, it would have been impossible to carry the stone on barges and place it from floating derricks. The method previously used on

the Galveston jetties was adopted and a trestle for a railroad of standard gauge was constructed along the line of the jetty. This method has the advantage of permitting work to be done at times when rough weather would have stopped all work from barges. For the portion in the water, the piles were creosoted with 24 pound treatment. The bents were driven on 14-foot centers and capped with a 12 by 12 inch timber, 10 feet long. The piles were cut off at a height of 8 feet above mean low water. Upon the caps were placed two 12 by 14 inch stringers, upon which the rails, weighing 56 pounds to the yard, were laid. Each stringer was composed of two pieces, each 6 by 14 inches and 28 feet long, laid side by side, breaking joints and bolted together at each bent with screw bolts. The piles were driven to a penetration of 15 feet, inclined toward each other at the top, with a batter of 3 feet in 24 feet, their tops being about 6 feet apart. (For details of the trestle, see Fig. 6.) The lumber was sound heartwood of longleaf yellow pine, and the piles green shortleaf or loblolly pine, 12 inches at large end and 9 inches at the small end.



Piles exposed to sea water to be creosoted. Penetration to be not less than 15 feet.

Fig. 6. Railway Trestle Used in Building South Jetty

A transfer wharf was erected on the mainland and the stone cars coming from the quarry were transferred to a transfer barge and towed across to a similar wharf on Mustang Island. The barge was fitted with standard tracks and carried nine cars at a load. The transfer wharf had a hinged apron, raised and lowered by winches, and when in operation it rested on the barge, making a continuous track for the locomotive. The contractor was paid for the wharf and trestle, but all side tracks, turnouts, switches, and transfer appliances had to be provided by the contractor at his own expense and became the property of the United States at the termination of the contract.

The stone used at first was a dense sand stone weighing 140

pounds per cubic foot, with some of the crest blocks granite of 166 pounds weight. The stone used lately is all limestone, very dense, hard, and brittle, weighing 170 pounds per cubic foot. As the stone is paid for by the ton, instead of by the cubic foot, it is advisable to use as light stone as is regarded capable of withstanding the waves. Practically, it is a question of using stone from the nearest quarry, as the freight on the stone is the largest item in the cost.

The pile trestle was pushed out at least 600 feet in advance of the jetty mound and from this an apron of stone, 3 feet thick and 30 feet wide, was formed by throwing the stone by hand from the cars. (Fig. 7.) At least one-third of the pieces in the apron were to be one-man stone, and no piece was to weigh more than 500 pounds. Quarry run is used, including spalls and chips, weighing only a few pounds. This apron takes the place of the brush mattress; it is unaffected by the teredo, and the small and large pieces fit together, forming a floor for the mound. The main object of this apron is to protect the piles in the trestle from scour; it does, however, support the center of the jetty. As the stone is thrown by hand from the side of the car and not placed by skips, it naturally falls into two mounds on each side of the track which are subsequently leveled down by the waves so as to form a continuous apron. In the deeper water the stone has farther to fall and, consequently, is more scattered; at the outer end the width of the apron is about 40 feet. It would be better if this apron were to project 10 feet on each side of the completed jetty, at least on the channel side, to prevent the slope blocks from undermining by

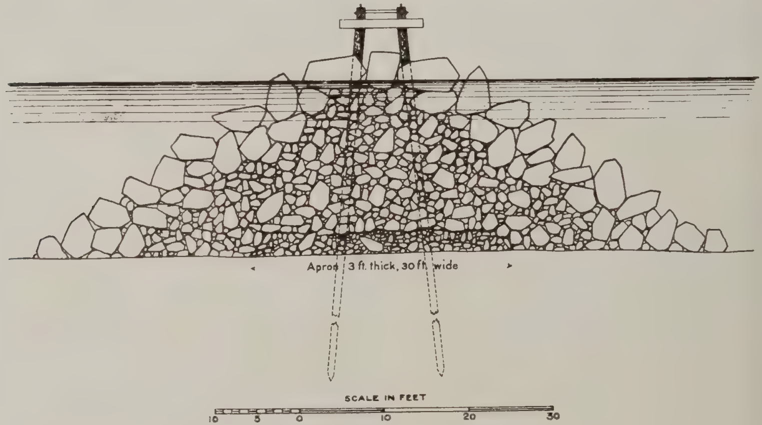


Fig. 7. Cross Section of South Jetty as Proposed by Major Jadwin, 1907

currents racing along the jetty. The slope blocks then settle in the sand and, exposing the crest blocks to wave action, they are rolled down the side of the jetty. It would be necessary to place this extra width either from barges or to use a light derrick with skips on a car. The barge method would probably be cheaper. The barge would be anchored fore and aft along the line of the jetty; and with lines moved across the line of the jetty, distributing the material uniformly.

On top of the apron is placed a core of quarry run of the stone weighing between 15 pounds and 2 tons. This portion of the jetty is drawn as the *mound*. It is unloaded from the cars by manual labor (Fig. 8), the larger pieces being pushed over the sides of the flat cars by pinch bars, pieces of steel about 5 feet long, drawn to a sharp point at one end and at the other flattened to a wedge shape and about 4 or 5 inches, bent to an angle of 45 degrees. This overlaps the apron on each side by about 6 to 10 feet. The mound extends to 1 foot above mean low water. As placed from the cars its top width is about 23 feet, with side slopes of 1 on 1.

Fig. 8. Unloading Stone for South Jetty, Aransas Pass, Texas

The slopes below mean low tide are covered about 6 feet thick with stone weighing not less than 3 tons, with average weight of 5 tons; but increasing in weight as the work advances gulfward to a minimum weight of 6 tons and average of 10 tons. Next is

placed the crest covering of three rows of blocks, placed on a bedding of small stone at an elevation of 1 foot above mean low water, and so arranged that the pieces bond together, to prevent any direct flow of water through the crest. The top of the crest is 5 feet above mean low water, and the width varies from 15 feet to 20 feet.

The slopes above water and alongside the crest are the last to be placed. These blocks and the crest blocks are approximately the shape of a rectangular parallelopipedon and weigh at the inner end of the jetty 5 and 8 tons, and for the outer half 8 to 12 tons. The side slopes are about 1 on 2.

Fig. 9. View of Completed Jetty, Aransas Pass, Texas

The slope and crest blocks are handled by a derrick, which is built on a standard flat car and operated by a 25-horsepower hoisting engine. Its capacity is from 10 to 12 tons. The car is secured to the trestle by chains and clamps, and loaded cars are brought to it one at a time by the locomotive to be unloaded. About 12 cars per day can be unloaded. In placing, the inspector uses care to see that the various pieces dovetail into each other with the minimum amount of voids. Large cavities and gaps between the blocks are filled up with smaller stone.

Where the incompleted structure is liable to serious damage from

waves, as small a length of jetty as practicable is under construction at any one time. Generally, the trestle is 200 feet in advance of the apron; the apron should be 1,000 feet in advance of the mound, and the mound protected below water as fast as possible. The portion above water can wait. In winter, the work should be kept well closed up. The profiles of the South Jetty show that when the apron is kept about 1,000 feet ahead of the mound in 15 feet of water the amount of scour when the mound is placed is about 3 feet, but when, owing to the stone failing to arrive from the quarry in correct proportions, the mound is advanced to within 200 or 300 feet of the end of the apron, the scour is as much as 7 feet.

The groin on land was built of a mound of riprap, of stone weighing from 15 pounds to 2 tons, without crest or slope covering. Its top was 8 feet above mean low water, width 14 feet, and slopes 1 on 2. Before placing the stone, the sand was removed under the central portion of the groin to an elevation of 3 feet above mean low water. On either side, trenches 10 feet wide were excavated to the level of mean low water, extending to the outside edges of the groin. These trenches were then filled with small riprap to an elevation of 3 feet above mean low water. The object was to carry the foundations well below the level of ground water and thus prevent undermining by the washing out of the sand on which the stone was placed.

The cars of stone are weighed on standard railway scales, furnished by the contractor, and the place in the jetty that the stone on each car goes is noted. From this the cost per linear foot of the jetty is determined. Generally, it is given in 100-foot lengths. Up to Station 30 (that is, for a length of 3,000 feet), the jetty was built under contract at the following unit prices: riprap (including apron, mound, and side slopes), $3.50 per ton, properly placed on work; crest stone, $4.37 per ton; railway trestle and track, complete, $6.35 per linear foot. Beyond Station 30, the prices were: for riprap, $3.08 per ton; crest stone, $4.09 per ton; railway trestle and track, $7.50 per linear foot. The following table gives the cost per linear foot between the stations named:

Station	Depth of water	Trestle per linear foot	Apron & mound		Slope		Crest		Total per linear foot
			Tons	Cost	Tons	Cost	Tons	Cost	
	Feet.								
0–20	4.0	$6.35	8.40	$29.40	3.40	$11.90	2.90	$12.67	$60.32
20–30	3.9	6.35	10.00	35.00	3.50	13.25	3.00	13.11	67.71
30–40	11.5	7.50	19.21	59.17	7.55	23.25	3.60	14.72	104.94
40–50	7.3	7.50	17.28	53.22	11.08	34.13	3.57	14.60	109.75

Cross sections of the completed jetty are shown in Fig. 10. The theoretical apron and mound are shown in dotted lines, based upon the original depth when the apron was begun, with top width of mound of 23 feet and side slopes of 1 on 1. These sections show a decided filling of sand on the Gulf side, and on the channel side a scour at the inner end, but a filling at the outer end. They also show that the jetty after standing a while bears little resemblance

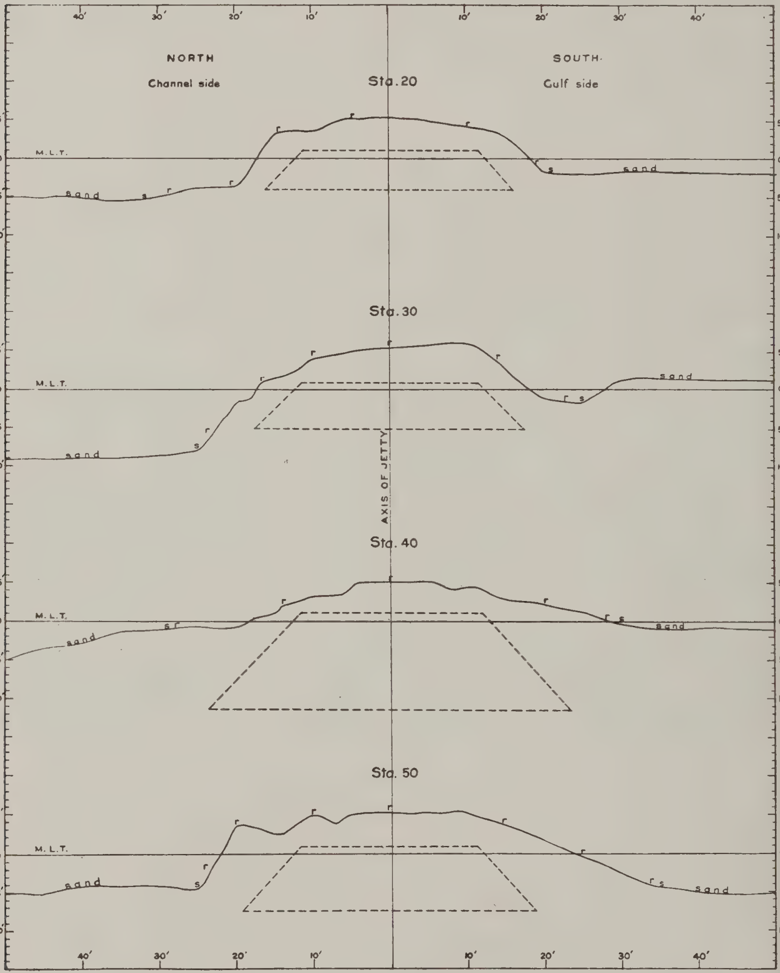


Fig. 10. Cross Sections of South Jetty, Aransas Pass, as Actually Built. Theoretical Outline of Riprap Mound Shown in Broken Lines

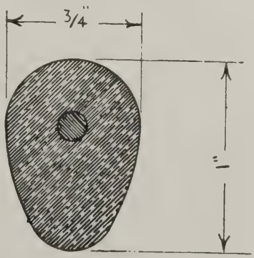
to the theoretical cross section. The changes in the sections are due to settling in the sand and to consolidation. In making estimates for a new work, it is necessary to allow for these changes, and if the sequence of work is properly carried out, the estimate should be based upon building the jetty in 3 feet of water greater than shown on the map. In calculating the amount of stone required for the apron and the mound, where all sizes of stone are used, the amount of voids is about 40 per cent, so that for limestone the weight per cubic yard in place would be 3,174 pounds. The crest blocks have a smaller percentage of voids. Measurements just taken over the outer end of the jetty, near Station 60, give the average width of crest as 17.3 feet; average depth of crest, 4.1 feet; average cubic yards per linear foot, 2.63; average tons per linear foot, 4.5. There are 1.71 tons of stone per cubic yard in the crest in place. As the weight of 1 solid yard of the limestone is 2.3 tons, the percentage of voids in the completed crest is 25.

Ice Accumulation on Wires

The accompanying cut shows to actual scale the amount of ice collected by a No. 9 steel telephone wire in a sleet storm on January 14, 1911, at Keokuk, Iowa. The total area of the figure is 0.5575 square inch. The area of the wire itself is 0.0103 square inch, making the total area of the cross section of the ice 0.5472 square inch. From the above figures it will be found that the volume of ice per linear foot of wire is 0.00381 cubic foot. Assuming the average specific gravity of ice to be 0.92 (Trautwine), the weight of ice per running foot of wire is 0.2185 pound.

These figures will be of considerable interest to engineers concerned in transmission lines in northern climates.

The above information is furnished from the United States Engineer Office at Rock Island, Ill., by Maj. Charles Keller, Corps of Engineers.



REBUILDING LOCK GATES, MILAN SECTION OF ILLINOIS AND MISSISSIPPI CANAL, DURING SEASONS OF 1910-1911

BY

Mr. J. C. McELHERNE
Assistant Engineer

The Milan Section of the Illinois and Mississippi Canal at Milan, Ill., connects with and extends from the head of the lower rapids of Rock River to the Mississippi River at the mouth of Rock River—its length being 4½ miles. There are three locks on this reach: No. 35, a guard lock at its head; No. 36, 3 miles below, and No. 37, at its lower end. The difference in elevation between the normal stage of water at its upstream end, Rock River Pool, and the low water of 1864 at its lower extremity is 18 feet. This fall is overcome by a 6-foot lift at Lock No. 36 and a 12-foot lift at No. 37, thus making navigation possible between the Mississippi River and the Illinois River near Hennepin, Ill., via Rock River Pool, and thence through the longer portion of the Illinois and Mississippi Canal, a total distance of 75 miles.

The locks are of concrete, 35 by 170 feet long between quoins, and their gates, built of wood in 1894, range, except a 10 2-3 foot pair, from 14½ to 23½ feet high, and are all 20 1-3 feet long. The much decayed gates of these three locks are now being rebuilt, and the work is almost completed. The lumber used in construction is oak, with pine sheathing, and was, last season, first all framed and creosoted at our canal boatyard, then distributed to the different locks, where, to prevent its warping, it was without delay correctly assembled, as most convenient, near the lock walls—there being no other available room for the purpose. Next the old gates, in pairs, were taken out intact; the large castings, rods, and other irons removed, *repaired* or *renewed as needed,* and neatly fitted into the new gates, which latter were then installed as herein described.

In reference to the method of performing the work: A set of five

timbers, 6 by 12 inches 40 feet long, was first laid across the lock, close to each end of the gate recesses to serve for supporting purposes and as a passage way. A large oak jack-timber, 30 feet long, was then blocked on upper edge of the *old* gate in place in its recess, and over it were fastened chains passing underneath the gate, near each end; and down through this timber and some of the upper longitudinal ones of the gate, about 7½ feet each way from center, an iron rod with washers and nuts for both ends was run and securely tightened to help strengthen and steady the combination in different positions, after which two cribs of light blocks were started and gradually built at each end of the gate recesses, as the gate itself was being jacked up. These two cribs were to sustain its weight and there were others in rear of the recess to serve as stands for the men and bases for the car jacks used in lifting the load (Fig. 1). When the gate was raised to the required elevation, or about half its own height, two sets of planking, of sufficient thickness, were spiked on its back to fully protect the valves, their rods, connections, etc.; and stout knees were also so fastened into and against the gate on the same side as to lap over on top of the lock wall and thus prevent any sliding down of the gate while it was being pulled backwards down over skidways and on bottom rollers, as needed. It was then stripped of its top jack-timber, chains, and rods, and of its own irons, etc. (Fig. 2.)


Fig. 1. Old Milan Gate, Illinois and Mississippi Canal, Raised Preparatory to Removal

A *new* gate when fully assembled and provided, exactly like the

old one, with the same jack-timber, chains, and rods, was next placed between the same afore-mentioned lock cross-timbers—its jack-timber being shaped to rest and travel on them. The gate was then forced, on rollers, with lines and pinch bars, well out over the lock chamber onto temporary cribs erected on a barge in the lock. The bottom edge, only, of the gate was then lowered to the barge by means of jacks, and the cribwork carefully removed, while the gate in the meantime was being continually forced still farther over so as to make it finally clear the barge (Fig. 3). This having been done, the barge was withdrawn, leaving the gate suspended vertically on the lock cross-timbers. It was then, with a dolly under each end of the jack-timber, very easily drawn back into its recess, let down on its pintle, and finally securely fastened in its proper position.

The work of removing the old gates and substituting new ones at Lock No. 35 was completed just before the close of and without interfering in any way with navigation, and that on the other two was carried on throughout the entire winter with the loss of only twelve days, seven of which were spent on work elsewhere. The cost of renewing these lock gates, including material, creosoting, labor, and office expenses was, for Lock No. 35, $2,499.80; Lock No. 36, $2,174.75; and Lock No. 37, $3,391.70. Total amount, $8,066.25.

Fig. 2. Skids for removal of gate

Fig. 3. Placing new gate in position

THE DISCHARGE OF UNPURIFIED SEWAGE INTO THE HUDSON RIVER NEAR YONKERS*

BY

Col. W. M. BLACK
Corps of Engineers

As a step in the agitation for a cleaner harbor by the City of New York, and following closely upon the action taken in the case of the Passaic Valley Trunk Sewer, the Department of Justice of the Federal Government proceeded against the Commissioners of the Bronx Valley Sewer, seeking to restrain them from discharging untreated sewage into the waters of the harbor. In a letter from the Attorney-General to the Secretary of War, dated July 21, 1910, it was requested that the engineer officer in charge of the district be directed to report upon the proposed sewer as affecting "the pollution and sanitary results to commerce which may hereafter develop on the Hudson River or other navigable waters, from said plans, in addition to what may be termed ordinary statutory obstructions to navigation."

In this connection reference is made to a report of the writer dated June 21, 1909, on the same subject, submitted to the Adjutant-General, Department of the East. In paragraph 3 of that report, the general extent of the project for the Bronx Valley Sewer is described, and it is stated that it is proposed to discharge the sewage "through two cast-iron pipes into the Hudson River, in depth of about 42 feet, about 236 feet beyond the bulkhead line established by the Secretary of War in 1897. This line, at the point of outlet, is about 170 feet outside of the low water shore line." The proposed outlet is located about 300 feet north of the northern limit of the City of Greater New York and about 2 miles north of the entrance to Spuyten Duyvil Creek.

In November, 1910, the outlet pipes had been laid from the shore to a point some distance inside of the bulkhead line and connected with a tunnel which is being constructed under the high land from a point about 500 feet distant from the shore to connect with the

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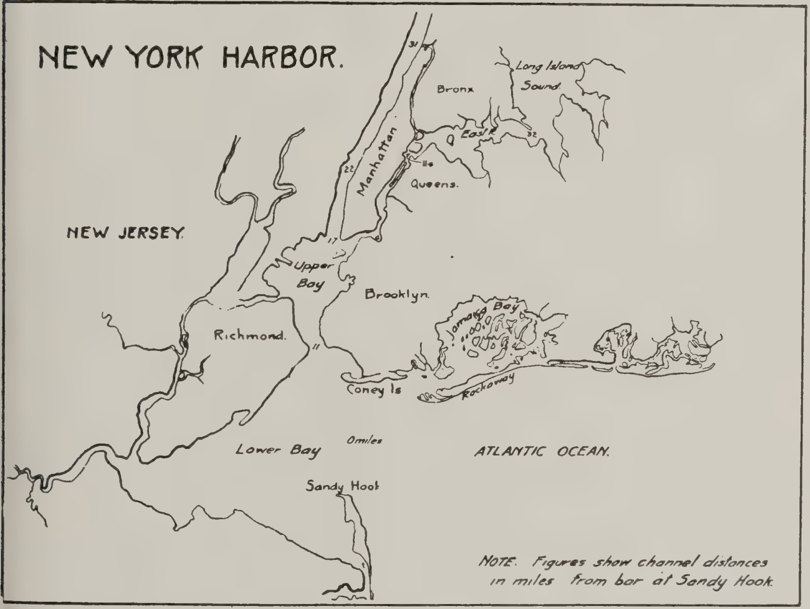
* From a report submitted to the Chief of Engineers, December 27, 1910.

sewers farther inland. This tunnel was being lined when inspected by me, and I was informed by the resident engineer that it was expected to have everything ready for the passage of sewage by about May, 1911.

Under date of May 14, 1909, the Bronx Valley Sewer Commissioners applied to the Secretary of War for a permit to construct the sewer outfall between the shore line and the point of discharge. The Attorney-General having requested that the War Department take no action in the matter until after the results of the action taken by the United States before the courts in this case should be announced, no action was taken on the application for a permit. The applicants, however, were informed that under the law they had the right, as far as the United States was concerned, to carry their outlet as far as the bulkhead line without a further permit. The cast-iron pipes for the construction of the outlet are on the ground.



As stated in section 4 of the report of June 21, 1910, referred to above, the enabling act

> * * * makes provision for the exclusion from the sewage of "all surface drainage except sewage." The sewer is designed to provide for the sewage of a population of 850,000, the existing population being about 30,000.

The sanitary sewage from the present population of 30,000 may be roughly estimated at 3,000,000 gallons per day, assuming a water consumption not greater than 100 gallons per capita. The ultimate sewage discharge for a population of 850,000 on the same assumption would be 85,000,000 gallons per day. The actual discharge will probably be greater than this, due to the inflow of ground water and to drainage other than sanitary sewage, which will undoubtedly be carried by the system to a greater or less extent. The effects of discharging this amount of sewage into the Hudson at the one point may be considered under three general heads:

I. Shoaling of the river, caused by deposits therein;

II. The showing on the river surface, caused by the discharge of so large a quantity of sewage at a single point;

III. The pollution of the stream.

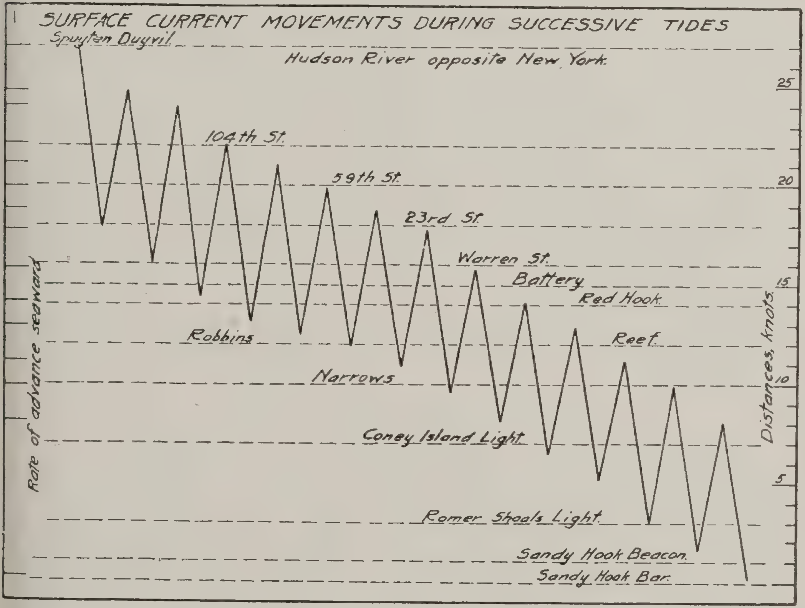
I. SHOALING OF THE RIVER, CAUSED BY DEPOSITS THEREIN

As has been shown in the earlier report, the shoaling to be expected in the river, from the discharge of sanitary sewage only, would probably be so small as to be negligible as an obstruction to navigation. Should the system be badly installed, or should surface drainage be allowed to enter, the amount of deposit to be expected would be markedly increased, since such an increase would be the result of neglect on the part of the authorities charged with the construction and operation of the sewer; injuries caused thereby should be made good at their expense.

II. THE SHOWING ON THE RIVER SURFACE, CAUSED BY THE DISCHARGE OF SO LARGE A QUANTITY OF SEWAGE AT A SINGLE POINT

Sewage has a less specific gravity and, generally, a higher temperature than the water into which it is discharged, be it either fresh or salt, and therefore when discharged into a waterway it has a tendency to rise promptly to the surface. If discharged in large volume, even at considerable depth, a break will be noted on the surface similar to that caused by the inflow of a large spring, and the sewage will float on the surface over a considerable area. The sewage is usually of a dingy gray color and contains many particles of matter, even after having been subjected to coarse screening. The sewage thus becomes plainly and offensively visible, and usually gives off considerable odor. At the Bear Island discharge in Boston Harbor, 60,000,000 gallons per day are discharged in

continuous flow close to the water surface, and the discharge is visible on the surface for 1¼ miles. At the Moon Island outlet in Boston, sewage is discharged at the beginning of each ebb in average volume of 88,000,000 gallons per day. At the time of discharge an area of as much as 2,000 acres is at times covered with sewage. This discharge is also at the water surface. At the Nut Island outlet in Boston Harbor, 40,000,000 gallons are discharged per day, with a maximum discharge of 140,000,000 gallons, at a depth of about 30 feet at mean low water, this discharge taking place through a single opening pointing upward. The sewage is plainly visible, but the area covered is markedly decreased, being about 500 feet square at the time when I personally made an inspection at this point. At all of these outlets odors are perceptible. Conditions similar to these should not be tolerated on the Hudson for obvious reasons.



All of this Boston sewage is screened before discharge, and some of it is sedimented. The screens have openings between the bars which give a clear space of about an inch, though the bars being staggered, the openings measured on a line at right angles with the direction of the flow are about 3-16 of an inch. The materials caught by these screens are mainly rags, papers, fruits, match

sticks, and bodies of small animals and, sometimes, even of infants. In Boston, the amount of solid materials caught on the screens varies from 2.8 to 4.3 cubic feet per million gallons. At Washington, the discharge is in the Potomac River above Alexandria. There screened sewage is discharged in fresh water about 28 feet deep through two outlets, and when inspected the area discolored was about 30 by 250 feet. The sewage in Washington is delivered at the outlet in a fresh state and no odors were perceptible when an inspection was made, nor was the discoloration very apparent since, at the time of inspection, the Potomac carried enough sediment to make the color of its waters closely approximate to that of the sewage. The waters of the Hudson opposite the point of discharge are reported by the Metropolitan Sewerage Commission to be an admixture of salt and fresh waters in percentage of from 50 to 60 per cent fresh water and 50 to 40 per cent salt. This admixture of salt water would cause a more rapid rise of the sewage to the surface than is found in the Potomac, but less than at Boston. The color of the water, however, is such as to make the sewage, if discharged, distinctly visible. Should the discharge of the Bronx sewage into the Hudson be permitted, it should be under conditions similar to those prescribed by the Department of Justice of the United States in the case of the Passaic Valley Sewer outlet. (See Appendix.)

III. POLLUTION OF THE STREAM

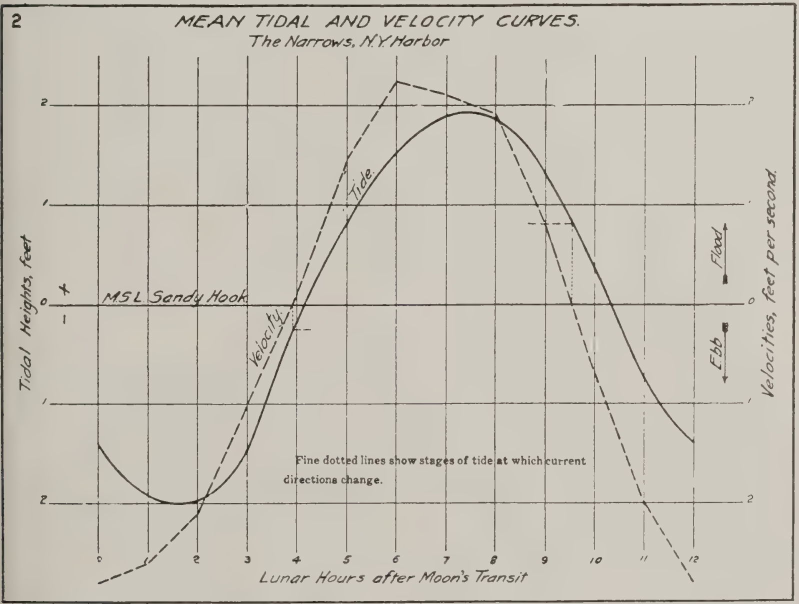
The pollution in waters, caused by sewage discharge, may arise from two causes: first, from trade wastes and, second, from the decay of organic matter in the sewage. The discharge of unpurified trade wastes into a sewer should be strictly regulated. Some of these wastes, such as that from gas works, are distinctly offensive, and should be treated locally before discharge. In his report on the sewage disposal of Paterson, N. J., dated June 30, 1906, Mr. Allen Hazen states:

> Taking into account all the data collected I estimate that the manufacturing wastes of the City (Paterson) will add 25 per cent to the volume of sewage to be treated, and that the material added is, on the whole, considerably more difficult to treat than domestic sewage. Taking this sewage as it will be with the mills connected with the sewers to the extent above indicated, I estimate that the difficulty and expense of treating the sewage will be increased 50 per cent because of these wastes, * * *

The effect of some industrial wastes on fish life is shown in the

report of Mr. M. C. Marsh, Assistant, Bureau of Fisheries, and has been published in a reprint from the U. S. Geological Survey Paper No. 192. Mr. Marsh says that some of the wastes from paper and pulp mills, from canneries, from knitting mills, and from the various processes for making gas are highly injurious to fish life.

The greatest source of pollution arising from sewage discharge is that resulting from the decay of the organic matter contained in the sewage. Sewage is reduced to a stable form by oxidation by chemical and bacteriological processes. When discharged into water, the oxygen required for these processes is taken from the water. Fresh water streams in their natural state have in solution at a temperature of 68° F. 4.04 grains of oxygen per cubic foot and salt waters have 3.29 grains per cubic foot. The mixture of fresh and salt water in the Hudson River opposite the outlet is assumed to contain about equal parts of salt and fresh water, so that the normal saturation value of dissolved oxygen will be the mean of the above quantities, or 3.67 grains per cubic foot. The composition of sewage varies greatly, but, in a general way, it may be stated that for reduction to a stable form, each million gallons of sewage will consume between 1,500 and 6,000 pounds of oxygen under summer conditions, of which from 500 to 2,000 pounds is absorbed in



twelve hours after dilution at the rate of 1 part of sewage to 100 parts of water. The result, then, of discharge of sewage into a navigable waterway is the diminution of its oxygen supply. When this diminution is 100 per cent, there is no oxygen left in the water and, in this condition, the water is offensive to the eye and nose, it is injurious to human health, destructive to fish life and injures the paint on all vessels navigating in it.

Certain authorities have placed 30 per cent as the minimum percentage of the saturation value of oxygen to which it is permissible to reduce the waters of a navigable river, that being the standard reported to have been established for the Thames at London. It would be unwise to adopt this standard for New York without full investigation. The climatic conditions of New York are quite different from those of London, and in a New York summer water in which oxygen is reduced to this percentage may become offensive. It is of record that such was the case at times in the Merrimac River when the quantity of dissolved oxygen had been reduced to 50 per cent of the saturation value.

In a recent letter, Dr. H. M. Smith, Acting Commissioner of the Bureau of Fisheries, states:

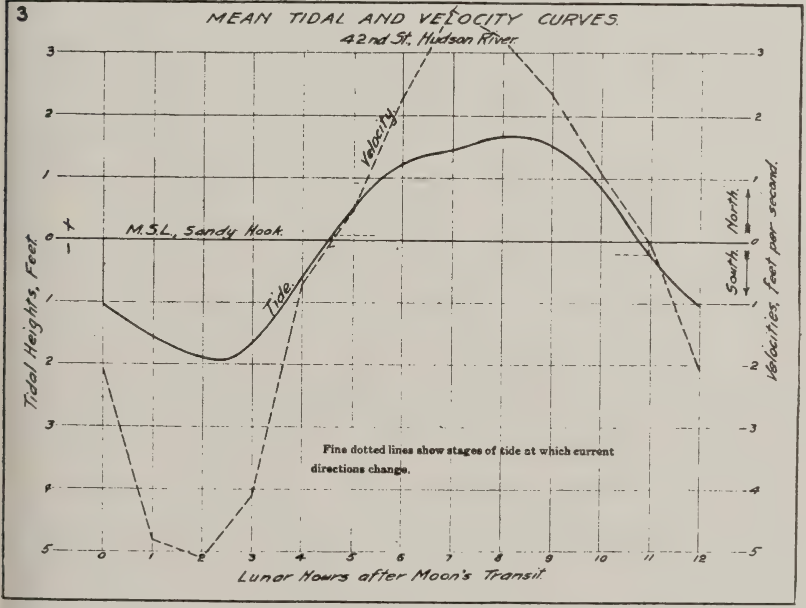
> While natural air saturation is the only proper standard for the best results, fish life may be maintained, probably indefinitely, with a lower standard. Excluding the salmanoid fishes and the seasonal changes in fishes during which, as sometimes in winter, they become sluggish or dormant, with diminished metabolism, it is believed that a withdrawal of 30 per cent, or an oxygen content of 70 per cent, is close to the limit of safety and would not result in any marked injurious effects on fishes. Salmanoids also would endure such conditions at least for a time, as in migration. The Bureau realizes that this subject is rather complicated and data from experiment and observation are meagre. It is believed, however, that 70 per cent, as a general standard, should be regarded as an extreme minimum.

It is evident then that the amount of sewage which can be discharged safely into a body of water at any point is dependent on the volume of water flowing past that point through which the sewage can be diffused, on the condition of that water with respect to the dissolved oxygen contained therein, and on the rate at which the water can renew its oxygen supply by absorption from the air, from vegetable growths, or from admixture with fully saturated water. A stream passing over falls or through rapids will renew its oxygen supply rapidly through the constant admixture

of the surface layers with those lower down, or by carrying particles of air down through the body of the water from which oxygen is absorbed. Lederer, in the first report of the Lake Michigan Water Commission, stated that

> In 1900 analyses of water taken respectively above and below the bear trap dam at Lockport, Ill., showed that the aeration produced by the flow over the dam had increased the dissolved oxygen from 5.9 to 70 per cent of saturation.

It is evident that these sources of re-aeration are only found in a stream with a rapid current, flowing through a bed containing roughness sufficient to produce a constant interchange of water between different layers; that a broad, deep stream flowing through a smooth bed will, in general, have to depend for re-aeration upon surface action alone. Recent investigations have shown that the amount of re-aeration of a stream from this source is at so slow a rate as to be of practically negligible value. In the case of the Hudson at Yonkers, then, the amount of oxygen available for sewage reduction will be the amount present in the water; and the time during which this supply is being drawn on will be the time required for a particle of water passing the sewer outlet to reach the practically inexhaustible reservoir of the sea.



Fine dotted lines show stages of tide at which current directions change.

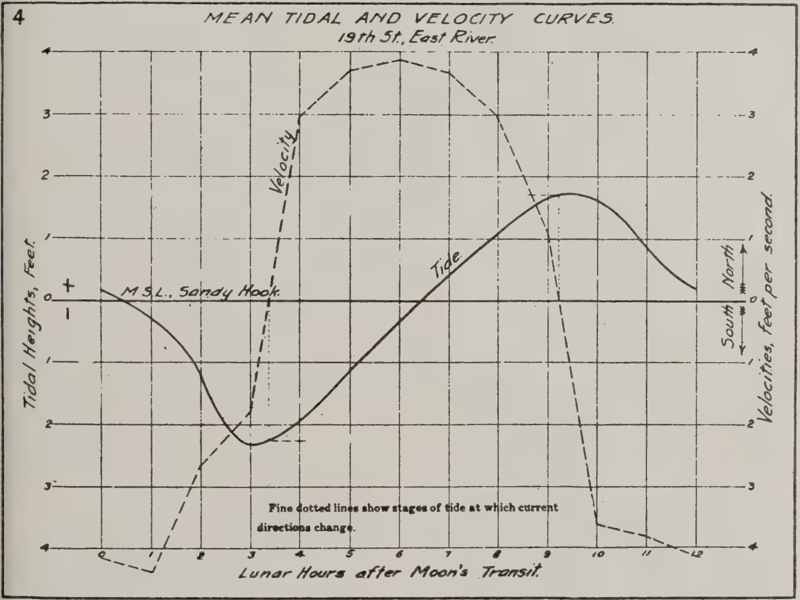
On September 22, 1910, by direction of the Department of Justice, Prof. Earle B. Phelps had a series of tests made of the amounts of dissolved oxygen in the waters of the Hudson through one tide, in the section opposite Mount St. Vincent, near the proposed Bronx Valley outlet. Four stations were occupied at equal intervals from the east to the west shore. At each station samples of water were collected from the surface and at 10-foot intervals to the bottom. Two and a half complete trips were made across the entire section. Work was begun at 7.45 a. m., and ended with darkness at 6.20 p. m. Flood currents had just started when work began. The ebb set in at 2.15 p. m. Observations were made for dissolved oxygen and also for the admixture of salt and sea waters—in order that the percentage of saturation of the dissolved oxygen might be determined. The total number of samples taken was 42. The percentage of sea water varied from 40.5 per cent to 55.5 per cent, with an average of 42.2 per cent. The percentage of saturation for the dissolved oxygen varied from 39.6 per cent to 66.8 per cent, with an average of 51.2 per cent. This, it will be noted, is without any sewage flowing from the Bronx sewer system, and is the result of the pollution of the waters of the Hudson above Mount St. Vincent, of the Harlem River, and of the waters of New York Harbor.

The accompanying diagram, No. 1, shows the approximate movement of a particle of water between Spuyten Duyvil and the Sandy Hook Bar as acted upon by the tidal currents, and shows that the rate of progress seaward is but small, and that thirteen and one-half complete tides, or about one hundred and seventy hours, are required for the particle to reach the sea after passing Spuyten Duyvil. Other investigations show that the maximum velocity of the *ebb* current (southward) past the outfall is about 2.8 knots per hour, and that the average velocity is about 1.6 knots per hour, while the average *flood* velocity is about 1.3 knots per hour. With the flood current, one tide will carry a particle of water from a point opposite the outfall north about as far as Tarrytown, and that the ebb tide will carry a particle starting from the outfall about as far south as 42nd Street; the progress of the particle farther in either direction being stopped by the change of tide and its direction of travel reversed.

Sewage discharged, then, into the Hudson at the proposed outfall would oscillate to and fro across the outlet between the limits of Tarrytown on the north and the sea on the south before being

finally reduced, a portion of it passing into the Harlem River on each flood tide and adding its quota to the general pollution of that stream.

The actual pollution resulting from the Bronx Valley sewer discharge will vary with the temperature, and the effect of the pollution will vary with the volume of flow of the stream. The pollution will thus be most evident in the summer, when the temperature is high and the discharge of the Hudson at its minimum volume. It is, then, the effect of the discharge under these conditions which must be investigated.



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MEAN TIDAL AND VELOCITY CURVES.
19th St., East River.

Fine dotted lines show stages of tide at which current directions change.

Further, the circulation of the waters in New York Harbor is controlled by the changes in elevation of the sea and sound at the Sandy Hook and Throgs Neck entrances to the harbor, respectively, caused by tidal action. These changes in elevation at the two entrances are not synchronal, nor are they equal. The accompanying map, with diagrams Nos. 2 to 7, will explain some of the tidal phenomena.

Diagrams Nos. 2 to 5, inclusive, show the relation between tidal heights and current velocities, both referred to the same zero line, at different points in the harbor. It will be noted that in only one case of those shown, East 19th Street, is the change of current synchronous with high and low water. At the Narrows (Fig. 2),

the tide has turned and risen nearly to mean sea level before the current changes direction, and on the reverse the water surface has lowered more than 1 foot, while the current is still running flood through the Narrows. At West 42nd Street (Fig. 3), the same phenomenon is noted, the current changing direction at about mean tidal height instead of at high and low water. At Throgs Neck, the Long Island Sound entrance to New York Harbor, the changes of direction of the current occur three hours after high water, when the tide has fallen about 3 feet, and two and one-hours after low water, when the tide has risen 4 feet. The cause of these apparent discrepancies may be found in the time required to reduce to zero the living force of the flowing water and to reverse the direction of the flow and, also, to the time required for the change of head of the tidal wave producing the velocities. It must be remembered that the true tidal wave in its passage around the earth produces an induced wave in all streams and estuaries met, but that the velocity of travel of this induced wave is much greater than is the velocity of the currents produced by it. Like the flood wave in the Mississippi River, the velocity of wave movement is a function of the channel depth, and is greatly reduced in shallow water. Thus, in its passage up the Hudson the wave motion is propagated at a rate varying with the depth until stopped by the dam at Troy. Between Sandy Hook and Governors Island this wave movement has a velocity of about 20 miles per hour, while the maximum velocities produced are but 3 to 4 miles per hour. Between Governors Island and Spuyten Duyvil the wave velocity is about 19 miles per hour. The maximum current velocity for flood and ebb, respectively, is about 2.3 and 3 miles. Farther upstream the velocities per hour of the wave propagation are approximately: Spuyten Duyvil to Peekskill, 18 miles; Peekskill to Hudson, 15 miles; Hudson to Troy, 10 miles. Diagram No. 6 shows a set of simultaneous tidal curves for various points in New York Harbor referred to the same datum and time ordinates. The difference of level between any two points at any particular time is represented by the length of the ordinate subtended between the curves at that time. Diagram No. 7 shows the slopes of the water surface from Sandy Hook to Throgs Neck at the zero, sixth and seventh lunar hours after the moon's transit, by the two routes followed, one via the East River and the other via the Hudson and Harlem rivers. The very steep slopes in the East and Harlem

rivers, as compared with the Hudson River and the Upper and Lower bays, are clearly shown.

As a result, the flow through the Harlem River is at certain periods to the south, and at other periods to the north. Similarly, the discharge from the Harlem into the Hudson flows partly to the north and partly to the south, and inflow into the Harlem from the Hudson comes partly from the north and partly from the south. The flood flow in the Hudson, opposite the proposed outlet of the Bronx Valley sewer, during any particular tide is thus made up partly from water which has worked up through several tides from the Sandy Hook entrance, partly from water coming from the Harlem River, and partly from the water which had passed the outlet during the preceding ebb current and which, in turn, contains a part of the Hudson's fresh water discharge of the earlier ebb. The flow during any particular ebb is made up of the water carried north past the outfall during the preceding flood, augmented by the twelve-hour fresh water discharge of the Hudson.

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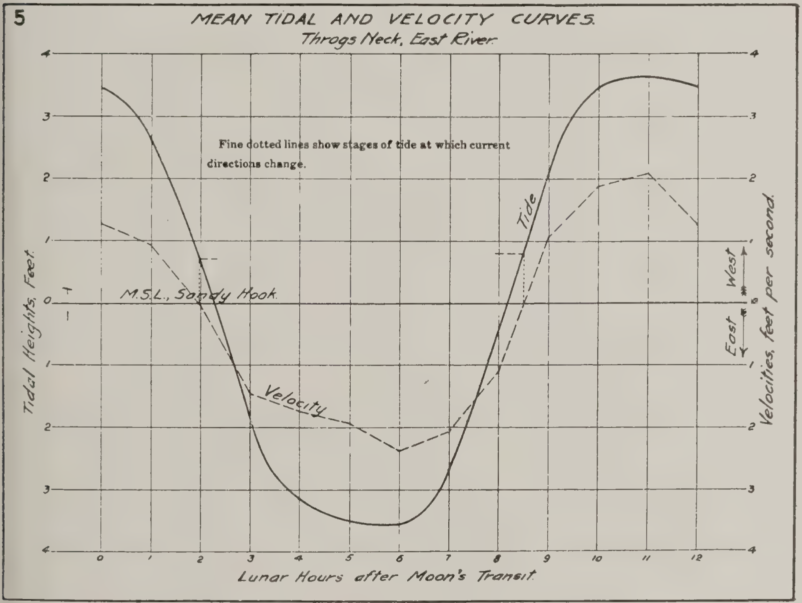


MEAN TIDAL AND VELOCITY CURVES.
Throgs Neck, East River

Fine dotted lines show stages of tide at which current directions change.

It is evident then that the waters passing the outlet are required to take care not only of the sewage discharge there, but also of sewage which will be discharged into them at points between the outlet and the sea and sound, by one route along the Hudson and

the Upper and Lower bays to the sea, and by the other route along the Harlem and East rivers to the sound. To prevent a nuisance, the total volume of sewage to be discharged into them at all points must be such that the elimination of oxygen caused thereby will not pass an allowable percentage of the saturation value. This allowable percentage of diminution will not be greater than 30 per cent, if the higher forms of fish life are to be conserved, nor than 50 per cent if evidences unpleasant to the eye or to the sight are not to be permitted at any season.

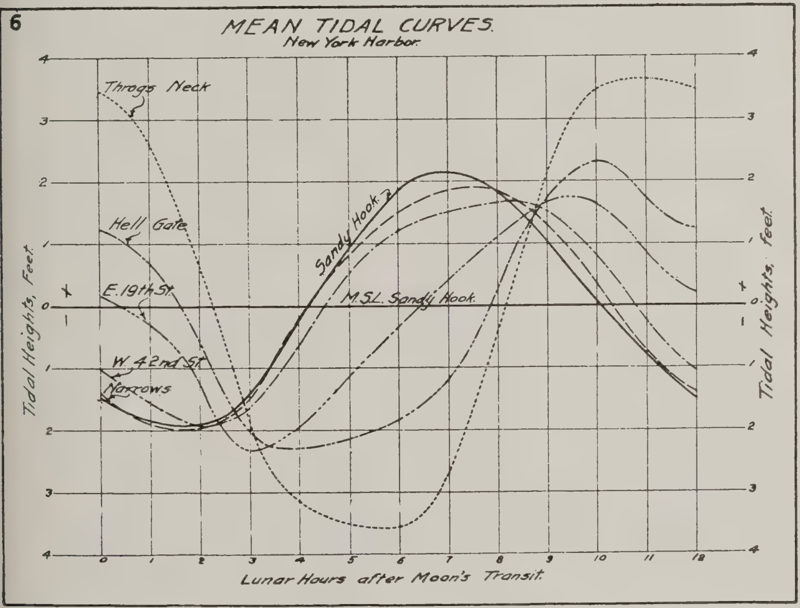
The analyses of the waters already mentioned show the reduction of oxygen already made. At the worst conditions found, the mean oxygen contents of the water were found to be 42.2 per cent of saturation value. To show worst means conditions, this figure will be used in the following computation. Since the flow oscillates north and south across the outlet, it is evident that the volume of water available for the reduction of the sewage flow for any twelve hours is the volume of the resultant southerly flow during these hours, or the difference between the volumes of flood and ebb discharges, which must be equal to the fresh water discharge of the Hudson during the same period. This minimum summer discharge is given by the Coast and Geodetic Survey as 700,000,000 cubic feet during one tidal period of twelve hours.

As previously stated, the amount of dissolved oxygen which the mixture of salt and fresh water found in the Hudson opposite the sewer outlet will contain at saturation is 3.67 grains per cubic foot, and the minimum mean amount of oxygen contained in these waters was 42.2 per cent of the amount at saturation. The total amount of dissolved oxygen at saturation in the 700,000,000 cubic feet available is 367,000 pounds; 42.2 per cent of 367,000 is 154,874 pounds.

On the assumption that 1,000,000 gallons of sewage will absorb from the waters 2,000 pounds of oxygen in twelve hours, the result of discharging 1,500,000 gallons per tide will be the absorption of 3,000 pounds in that time. As stated above, under the worst conditions found, the amount of oxygen available is about 155,000 pounds. The quantity absorbed by the sewage in twelve hours would amount then to 1.93 per cent of this sum, or the dissolved oxygen in the water would be reduced to 41.4 per cent of its saturation value. With an ultimate discharge of 85,000,000 gallons per day, the oxygen absorbed in the period of one tide would be 85,000

pounds, leaving the dissolved oxygen at 19 per cent of the saturation value.

Before the waters can reach the sea, further absorption of oxygen will occur. If the total absorption be taken at 3,750 pounds per million gallons, which is a conservative assumption, the amount of oxygen required for the 1,500,000 gallon discharge per tide would be 5,625 pounds, and the oxygen left would be 40.7 per cent of saturation. For the ultimate discharge of 42,500,000 gallons per tide the similar figure would be 159,375 pounds, or more than the amount of oxygen available in the waters passing the outfall.



The above figures give the worst mean conditions to be expected. If the mean value of the dissolved oxygen during the entire tide be taken the showing would be somewhat better. The average value of the dissolved oxygen for an entire tide was found to be about 51.2 per cent of saturation. For a discharge of 1,500,000 gallons in twelve hours, the dissolved oxygen would be reduced to 50.4 per cent in the same period; for a discharge of 42,500,000 gallons in twelve hours the corresponding figure would be 28 per cent; for ultimate absorption for the smaller discharge, the dissolved oxygen would be reduced to 49.7 per cent, and for the larger discharge the corresponding figure would be 7.8 per cent.

The above figures are, of course, approximate. They are believed to be conservative and to afford a fair idea of the results to be expected from the present and ultimate discharge of unpurified sewage from the Bronx sewer system. The present conditions in the Hudson opposite the sewer outlet are bad. Conditions in the section of the Hudson south of Spuyten Duyvil are believed to be worse—and those in the Harlem are known to be worse. At both localities they will be further impaired by the Bronx sewer discharge, unless that be first purified. Before the waters which flow past the sewer outlet reach the sea they will receive a further load of sewage.

Whatever be the standard of purity to be adopted for the waters of New York Harbor (viz: the 70 per cent of dissolved oxygen necessary for the higher forms of fish life; or the 50 per cent proved to be the limit in the Merrimac) purification of sewage discharged into these waters is required at the points most removed from the sea, as measured by the period required for the resultant tidal flow past them to reach the sea. Each community occupying the watershed has an equal right to take advantage of the natural reduction agency afforded by the harbor waters. As shown, in the vicinity of the Bronx sewer outlet, the circulation of the harbor waters due to tidal action is such that pollution at one point affects the entire neighborhood, and the volume of the resultant flow is insufficient to care for all of the sewage now discharged into it without serious pollution. The population is increasing rapidly, and unless remedial measures are taken at an early date the health of the communities will be threatened.

It would be unfair to require any one of these closely related districts to incur the expense necessary to purify its sewage completely before discharge. If all of the sewage from them were partially purified, the waters could be relied on to do the remainder of the work, without a pollution greater than can be permitted with safety to all interests.

Further and extended investigations would be required to fix the amount of purification which such a policy would demand, and a standard will have to be adopted for the purity to be maintained in the harbor waters.

In the absence of such information, it would seem to be fitting that the demands of the United States in the case of the sewage from the Bronx system should now be the same as those set for the Passaic Valley sewer system, reserving the right to demand a

higher standard of purification later, should that be shown to be necessary for the public good, since the location of the outlet of the Bronx system is so much farther removed from the sea.

APPENDIX

EXTRACT FROM CONDITIONS PRESCRIBED BY THE DEPARTMENT OF JUSTICE OF THE UNITED STATES IN THE CASE OF THE PASSAIC VALLEY SEWER OUTLET.

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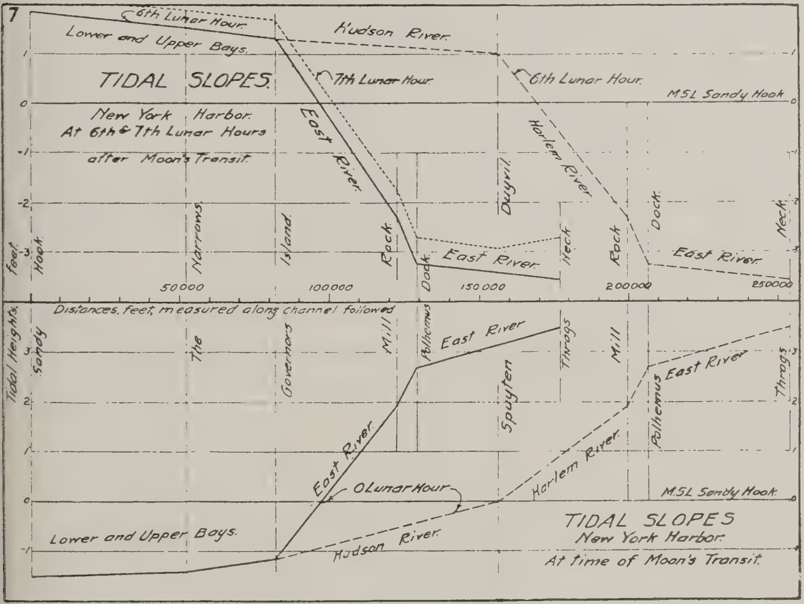
1. There will be absence in the New York Bay of visible suspended particles coming from the Passaic Valley sewage.



2. There will be absence of deposits objectionable to the Secretary of War of the United States in the New York Bay coming from the Passaic Valley sewage.

3. There will be absence in the New York Bay and its vicinity of odors due to the putrefaction of organic matters contained in the Passaic Valley sewage thus discharged.

4. There will be a practical absence on the surface of New York Bay of any grease or color due to the discharge of the Passaic Valley sewage at the dispersion area or elsewhere.

5. There will be no injury to the public health which will be occasioned by the discharge from said sewer into the Bay of New York in the manner proposed, and no public or private nuisance will be created thereby.

6. The absence of injurious effect, from said sewage discharge, upon the property of the United States situated in the harbor of New York.

7. The absence of reduction in the dissolved oxygen contents of the waters of New York Bay, resulting from the discharge of Passaic Valley sewage, to such an extent as to interfere with major fish life.

Third. The State of New Jersey and said Passaic Valley Sewerage Commissioners further agree with the United States that so long as said sewer system, or any part thereof, is operated, the United States shall have, through such representatives as may be designated by the Secretary of War at any time for such purpose, full opportunity to inspect the condition and working of the sewer system, with a view to determining whether this contract is being in all respects performed, and that the said Passaic Valley Sewerage Commissioners will render such expert or other assistance as the United States may desire in the course and in aid of such inspection and determination.

EARLY DREDGING APPLIANCES AND STEAM DREDGES[*]

* * * * * * *

The object of these works was to increase the depth of water on Van Buren Bar by the corroding force of the increased quantity of water thrown into that channel, but, in that, the works have not been successful. In 1825, dredging was begun on the bar. The depth of water in which the excavation was commenced was 4 feet, and it is now 8 feet. The top digging for about 1 or 1½ feet was a hard cemented gravel and sand; it then became loose and easy to be removed. The depth of water since the dredging, which was confined in a narrow channel, has been lessened by deposits brought from the upper parts of the stream. The dams are very much dilapidated; they were built about thirty years ago, and Mr. McCoun says, that when they were in perfect order they increased the depth of water at Troy 1 foot. Captain Reed, of Troy, in speaking of the Washington Bar, told me that the channel which has been dredged through it does not fill up much, which, he says, is owing to the hard bottom, and the raising of the water by the dams before alluded to. The corporation of Troy have expended, since 1829, about $5,000 in dredging between that city and Albany.

* * * * * * *

Below the foot of Patroons Island, a pier runs from the west shore for 540 feet into the stream; it was built in 1799 with a view to remove the Fish House Shoal, but has not fully answered the purpose intended. In 1826, excavation of that shoal was commenced by a dredge worked by horse power, and continued to operate until 1830. In 1831, the steam dredge was employed for the same purpose. The channel opened was, however, injured by an ice flood in 1831.

* * * * * * *

In a subsequent part of his report, he says: "if the navigation of the river was to be improved by dams, I am of opinion, that, to avoid any public trespasses of such a repulsive nature, and effectually to improve the navigation, without depending on system and casualties, the plan executed in Scotland, on the River Green-

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[*] Extracts from Report of De Witt Clinton, United States Civil Engineer, to Lieut. Col. John J. Abert, Topographical Engineer, upon the survey and improvement of the Hudson River. Document No. 189, House of Representatives, 22d Congress, 1st Session; March 30, 1832.

ock, below Glasgow, by Mr. Gouldbourne, a civil engineer of great repute, would be the most eligible, inasmuch as it has a tendency to straighten the channel of a river by the alternative concentration of low dams, and to deepen the bed by local excavations *performed by mud turtle* injurious to no one, but, on the contrary, reclaiming on each side of the river lands covered up by water, inasmuch as the stuff withdrawn from the bottom is lodged behind projecting piers by men constantly in that business.''

* * * * * * *

DREDGING

The changes, which occur in the beds of all streams, are of such a nature as would require more or less labor to remedy the injuries the channels might sustain. It would therefore be necessary that we should always have at command a power which we could apply to that purpose. That power is the dredge, and we can rely with confidence on its ability to perform such labor as we may require.

By the application of steam, the power and practical utility of the dredge has been much increased. It has also lessened the expense of excavations in a ratio corresponding with the improvements of its machinery and its strength; and, at this time, it may truly be considered as so important an agent as to have rendered many river improvements attainable, which before were considered impracticable.

To obtain full information on the subject of the Albany steam-dredge, I addressed a letter to General Gansevoort, of Albany, who had the kindness to procure for me the following information:

The expense of the dredge, and its appendages, was about $14,000. The annual expense of repairs about $250. The daily expense of fuel and labor about $20, and the durability of the machine, if used every season, about seven years; and it can perform work between seven and eight months in the year.

The power of the machine is about 15 horses, working under high pressure, with boilers on each side. The buckets are 2 feet wide and 1 foot deep, and oval form. A moderate and even power applied effects the best operation. Her present clearing is in 10 feet water, but it can be made to operate in 14 feet water if necessary.

The machine can remove from 50 to 60 cubic yards an hour in good digging. From hard bottoms and deep water, from 30 to 40 cubic yards in an hour, and has removed from the overslough bar 600 cubic yards in a day.

The expense of the dredge, therefore, for seven months, or say 182 days, at $20 daily, would amount to $3,640; and to which add $250 for the repairs of the machinery, making $3,890. If we suppose that the dredge could only work two-thirds of the time, the other one-third being interrupted by high water, and breaking of the machinery, and that the averaged excavation was 40 cubic yards per hour, and the time in which it operates ten hours, it gives 400 cubic yards as the daily labor of the machine, or 48,000 cubic yards

is its total amount of work yearly. We have seen that the daily performance of the dredge, and the repairs of the machine, amount to \$3,890. If to this we add the annual decay, and the loss of interest on the capital, it would give, in seven years' average, \$2,400. But, even after the machine was useless, some parts of it would be salable. If we assume this as one-eighth of its original cost, it leaves \$2,100, or \$5,990 as the total annual expense of the dredge, and the loss of interest, decay, and repairs of the machine, or nearly 12½ cents per cubic yard for the cost of excavation, on the amount of work which the machine is capable of performing to meet that sum.

Without entering into a minute calculation, we will assume, as the soil is now placed in scows to be taken away, that each craft will contain 20 cubic yards, or it will require twenty scow loads to carry away the soil which the dredge would excavate, or two in each hour; consequently, one gang of men, comprising four persons, would be sufficient to attend to this part of the duty, at \$1 each; it gives the expense of transportation of earth to the place of deposit, at one cent per cubic yard, or making 13½ cents per cubic yard for all expenses of digging and removing the soil.

This calculation may appear high, and is probably so. It is therefore safe. But it will be seen that I have supposed the work to be done by contract, and that the machines are owned by individuals. But if done directly by the Government, the work might be done lower than I have calculated it.

Richard Delafield

Richard Delafield (see frontispiece) was born in New York City, September 1, 1798. He entered the U. S. Military Academy May 4, 1814, and was graduated and commissioned Second Lieutenant, Corps of Engineers, July 24, 1818. He served as astronomical and topographical draftsman to the American commission under the treaty of Ghent for running the northern boundary of the United States in 1818, and was assistant engineer on the construction of the defenses of Hampton Roads, Virginia, from 1819 to 1824. He was promoted First Lieutenant, Corps of Engineers, August 29, 1820, and Captain May 24, 1828, and served as superintending engineer of the fortifications at Plaquemine Bend on the Mississippi River from 1824 to 1832, part of which time he was also in charge of the survey of the mouths of the Mississippi River and was engineer of the New Orleans Canal and Banking Company.

In 1831-1832 he was in general charge of the improvement of the Ohio and Mississippi rivers. From 1832 to 1838 he was at various times superintending engineer of the Cumberland Road east of the Ohio, of the fortifications of Fort Delaware, Del., repairs at Fort Miflin, Pa., and of the improvements of the harbors in Delaware River, and of the breakwater at the mouth of that river.

He was promoted Major, Corps of Engineers, August 7, 1838, and from September 1, 1838, to August 15, 1845, was Superintendent of the United States Military Academy. From 1846 to 1855 he was superintending engineer of the defenses of New York Harbor, and during the same period was in charge of the Hudson River improvement, 1852-1855; Light-house Inspector of the New York District, 1853; Chief Engineer of the Department of Texas, 1853-1854; member of the Board of Engineers for the Atlantic Coast Defenses of the United States, 1845-1855, and for River and Harbor Improvements, 1854-1855. In 1855-1856 he was a member of the Military Commission to the Crimea and the theater of war in Europe, and his report and observations, entitled "Report on the Art of War in Europe in 1854-1856," was published by order of

Congress in 1860. From 1856 to 1861 he again was Superintendent of the United States Military Academy and was president of the board to revise the program of instruction of the United States Military Academy in the spring of 1860.

He was promoted to Lieutenant-Colonel, Corps of Engineers, August 6, 1861. During the Civil War, and until 1866, he served on the staff of Governor Morgan to organize and equip the New York State forces for the field and to supply ordnance stores for the Atlantic and Lake defenses, and during parts of the same period was superintending engineer of the defenses of the Narrows, New York Harbor, of the fortifications at Governors Island, New York, and of the fort at Sandy Hook, N. J., and served as a member of the commission to examine Stevens' submerging iron steam battery.

On April 22d, 1864, he was promoted Brigadier General and Chief of Engineers of the United States Army, from which time to August 8, 1866, he was in command of the Corps of Engineers and in charge of the Engineer Bureau at Washington, D. C.; Inspector (ex-officio) of the Military Academy, and member of a commission on the encroachment of the ocean at Sandy Hook, N. J., and member of the Light-house Board.

March 13, 1865, he was brevetted Major-General, United States Army, "for faithful, meritorious, and distinguished services in the Engineer Department during the rebellion."

He was retired from active service August 8, 1866, under the law of July 17, 1862, "having been borne upon the Army register over forty-five years." After his retirement he served as a member of the commission for the improvement of the harbor of Boston, Mass., and as regent of the Smithsonian Institution, Washington, D. C. General Delafield died November 5, 1873.

SURVEYS AND BORINGS FOR LOCK LOCATION OHIO RIVER

BY

Capt. LYTLE BROWN
Corps of Engineers

The present approved plan for the improvement of the Ohio River may be found in House Document 492, 60th Congress, 1st Session. It provides for fifty-four locks and dams, numbered consecutively from Pittsburg to Cairo.

Prior to 1909 there had been constructed numbers 1, 2, 3, 4, 5, and 6, and in that year numbers 8, 11, 13, 18, 19, 26, 37, and 41 were under construction. On March 3 of that year Congress directed that numbers 9, 10, 12, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 27, 28, and 29 be definitely located and that plans for their construction be prepared. This work was assigned to a board of engineers composed of the district engineers at Cincinnati, Pittsburg, and Wheeling, and $160,000 was allotted for the work. And on June 25, 1910, Congress further directed that similar work be done in cases of the remainder of the locks and dams proposed for the Ohio, viz: numbers 30, 31, 32, 33, 34, 35, 36, 38, 39, 40, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, and 54; which work was likewise assigned to the board aforementioned, and $150,000 was allotted for the work. The work directed in 1909 has been done and that directed in 1910 has been partially done. The field parties of 1910 were too late in getting to work to accomplish as much as was done in 1909.

When the general plan, as set forth in House Document 492, was formulated, all of the locks and dams not already begun were tentatively located. For this set of locations there was available a map of the whole river and a profile of the channel line. The map did not give information sufficient for a critical study of all the features that enter into the location of structures of the importance of those proposed, although it, together with the profile, did permit of the selection of all possible sites in a general way. It was de-

ficient in topography and gave no indication at all of the foundation conditions.

Irrespective of the foundation conditions existing at any locality. the following conditions govern the location of the locks and dams on this river.

1. The minimum depth in the pool created by any dam should be 9 feet.

2. The distance (vertical) from the site of the navigable pass to the normal upper pool surface should not exceed 15.4 feet, and should, as a general rule, be uniformly 15.4 feet.

3. The vertical distance from the lower sill of the lock to the normal surface of the lower pool must be 11 feet.

4. The sill of the navigable pass should not be placed so high as to be of itself a greater obstruction to open river navigation than the most obstructive bars of the vicinity.

After the above conditions are fulfilled the judgment of the engineer comes into play in getting a location which will provide good approach and exit for the lock, and a navigable pass easy to negotiate in open river navigation—all at the lowest cost in the completed structures. A straight reach of river for about a mile in length, with a width of not less than 1,200 feet between low water contours, a fairly flat bottom with low water depth between 5 and 10 feet, and good banks, would be an ideal location if, in addition, bed rock was found all across at depths of between 10 and 20 feet below low water. All of these conditions are never found together, and disadvantages must be weighed against advantages. In general, the advantages for navigation have outweighed the advantages of engineering or cost. Good foundation conditions cut but slight figures against a good location from the viewpoint of navigation. The advisability of locating on the point side or in the concave bends was rarely considered, because the locations were nearly all in fairly straight reaches; a sharp bend or a sharp point was enough to throw a location out of question. In the bends and points actually met the point sides were more accommodating to extreme lengths of straight wall (1,800 feet).

Owing to the fact that the channel line, where a positive or well-defined channel line existed, should be at about the middle of the 700-foot navigable pass, the locks should be placed so that the channel line should fall about 300 or 400 feet from the river wall or, say, about that distance from the low water contour on the lock side.

With all of the above-named requirements in mind, the board of engineers could select such restricted reaches of river from the general maps on hand as might afford locations; this was done and these reaches were surveyed for critical examination and comparison in selecting the exact locations.

The surveys consisted in the topography of the banks from low water to an average distance of one-eighth of a mile back from the top of the bank on each side of the stream, or at least to extreme flood level, and the hydrography of the river between low water contours; and embraced such lengths of the river as a consideration of existing maps showed feasible for location sites. The resulting maps were plotted on a scale of 200 feet to 1 inch, with contours at 5-foot vertical intervals. The ranges for soundings were at right angles to the thread of the stream and 200 feet apart, the soundings themselves being taken at about 40-foot intervals on a range.

For the examination of foundation conditions a series of three holes, one in midstream and one near each bank, was put down on every third sounding range into bed rock, or to a minimum depth of 30 feet below low water in case no rock was struck at less depth. This set of borings gave a cross section of the sub-strata for every 600 feet of length of river, so that at whatever point a location might be considered there would be at least one cross section of the river bed in the length of the lock.

The maps with the boring records thereon were made in the field as the notes progressed, and were transmitted to the board of engineers as soon as practicable. After carefully considering all of the features of each site in detail the exact locations of the crest of the dam and of the face of the land wall were placed on the map, which was returned to the field parties for permanent marking on the ground of the lines mentioned. In considering locations, a tracing of the typical lock and dam, made on the same scale as the map, was used to place over the map; by shifting this tracing the location could be made to fit the ground according to judgment as to what was most desirable in the relation of banks, bed, and channel.

The field parties, after having placed the location on the ground and permanently marked the same by two concrete monuments set flush with the ground, elaborated the survey of the immediate vicinity sufficiently for the preparation of a map of the site on a scale of 50 feet to 1 inch with contours at 2-foot vertical interval.

Also, the area under the foundations of lock, dam, and abutment was covered with borings taken at intervals of 100 feet. This large scale map, made in the field, if practicable, was the basis of subsequent plans, estimates, and specifications and also of the land necessary for purchase at the site.

In the survey proper no new or extraordinary methods were employed. All of the topography was taken by stadia. Soundings were made from skiffs by rods or lines (in deep water) and located by intersections from a transit point, the boat being always kept on a located range. The transit man found it possible to read on each sounding, while a recorder kept the notes. The levels were picked up from bench marks of previous surveys and carried to the sites by Y-level, two or more old benches being used for check. The control for the survey at each locality was an accurate stadia traverse. In getting the distance across the stream along the crest of the dam a carefully measured base was laid out and the distance triangulated. The platting of the maps was done by coordinates, after the protraction method had been discarded for probable inaccuracy. Special effort was made to insure the comfort and health of the field parties; they kept in the field till ice blocked navigation, and drank the Ohio River water from near Pittsburg to Cairo with no general sickness or complaint. The quarter boats were screened against flies and mosquitoes and the boiling of drinking water was enforced.

The organization of a survey party was as follows:

1 chief of party.
1 clerk (time keeper, subsistence, property).
1 night watchman.
1 cook.
2 cook's helpers (waiters, general quarter boat police).
Draughting: 3 draughtsmen, 1 recorder.
Topography: 2 instrument men, 2 recorders, 6 rod men.
Hydrography: 1 instrument man, 2 recorders, 1 leads man, 1 flag man, 3 skiff men.
Level party: 2 level men, 4 rod men.
Steamboat: 1 pilot, 1 engineer, 1 fireman, 1 deck hand.

The boat equipment was a quarterboat, in which was the drafting room; a small steamboat for towing and supplies, and six four-oared skiffs. The instrumental and drafting equipment, furnished through the Engineer Department at Washington Barracks, was excellent, but it would go too much into detail to give it here.

Basing the cost of the survey on the square mile of area, it may be given approximately as follows:

General location surveys: hydrography, \$118; topography, \$180; levelling, \$103; draughting, \$51. Detailed survey of site: hydrog-

raphy, $692; topography, $1,026; levelling, $371; draughting, $683.

The great difference of costs in the two cases is not to be attributed to difference in the character of the work. The small areas of the final surveys and the influence of the cost of moving the parties are the conditions which make the unit costs so much higher in the latter case.

The taking of the great number of borings to determine the foundation conditions gave much experience in this particular class of work, and a description of the plant, methods, organization, and costs, should be of some value. These borings, from the information they were intended to convey, may be classed as preliminary and final. The preliminary set were widely distributed, they being only three on a river cross section and the cross sections being 600 feet apart; they were intended to indicate generally the substrata, with the particular object of showing in what locality and at what depth rock suitable for foundations existed over the total area of river in which it might be possible from other considerations to locate the structures. No samples were preserved from this set of borings and cores were taken only when in the judgment of the engineer they were necessary for his information in determining the character of the rock. But the results from every hole were carefully recorded and appeared on the margin of the map opposite the location of the hole. It had been decided that it was not economical to carry foundations deeper than 22 feet below low water in an effort to reach rock, therefore the borings were not, as a rule, carried deeper than 30 feet below low water. In case of pile foundations it was assumed that penetration would scarcely exceed 24 feet in gravel. In all cases where rock was found each hole was driven 2 feet into the rock to eliminate the possibility of mistaking a boulder or broken rock formation for bed rock.

The final set of borings was made after the board of engineers had decided on the definite location of the structures, whose outlines could then be laid out precisely on the actual site. These holes were put down directly in the foundation area so as to cover it systematically and thoroughly. The distance between adjacent holes was 100 feet. In this set of borings samples were carefully preserved from one representative hole under the lock, one under the dam and one under the abutment; while for each hole put down accurate records were kept. In case rock was struck at depths less than the required excavation the holes were driven to and be-

yond the depths to be excavated; in case rock was struck at depths greater than the required excavation, but at depths less than 30 feet, the holes were driven only 2 feet into the rock, and consequently in most cases the cores taken were only about 2 feet long, unless the rock formation in that depth was deemed of questionable nature for foundation purposes, then cores were taken up to such lengths as would reveal suitable rock or show that all was unsuitable within limited depths.

Two classes of drills were used, both of which gave satisfaction. One, known as the Davis Calyx machine, manufactured by the Ingersoll-Rand Company, was a rotary drill adapted to rock coring with a shot bit; the other was a "spudding" machine, made by the Cyclone Drill Company of Orville, Ohio. Both machines used a string of hollow rods between the bit and the drilling mechanism. These hollow rods gave facility in delivering a powerful jet of water at the cutting edge.

Fig. 1. Steamboat Placing Drills; Davis Calyx Core Drill in Foreground

In selecting drills for this work the conditions of the case determined what was to be used quite clearly. A great number of relatively shallow holes had to be put down through coarse gravel and sand, and any coring that had to be done was known to be in sand-

stone, limestone, or shale. One of the prime features in an outfit was a pipe-driving and pipe-pulling device; the driving and pulling of pipe was as serious a matter as getting up material through the pipe. The Cyclone machine was excellently provided in this respect, but much had to be done before the crews of the rotary drills could get pipe out of the ground quickly. In order to get down through tough coarse gravel a good spudding device is essential; this was excellently provided in the Cyclone machine; in the Ingersoll-Rand machine this had to be done by use of a string of tools on the friction drum and was unsatisfactory. The Cyclone machine was not provided with a coring device, so that for this class of work the Rand machines were used exclusively. The shot bit for coring will cut almost anything, except very soft shale or material of such a character that the little shot will bed instead of rolling. The Davis cutters, cylindrical steel bits with teeth cut in the lower edge, were found to be useful only in stirring up material in the casing, so that it might easily be washed up by the jet. These bits are useless things and very expensive; if they will take a core from any material at all, that material was not encountered; in addition to other defects, they seem to tempt a drill man to keep on experimenting with them at the expense of the time of his whole crew.

All drills were steam driven. Hand operation, in view of the heavy work and the great quantity to be done, was out of the question. Coal was cheap and transportation easy, and it was possible to find men who could handle steam without any difficulty. Certain contractors on the river had used gasoline engines; a reason for so doing is not apparent.

One of the factors of prime importance where a great number of holes have to be driven through tough gravel is the drive pipe. Nothing but the heaviest drive-well pipe will answer. It is expensive, but not so much so in the long run as any lighter class of pipe. Well casing will crumple and split under the heavy blows and jerks and so will steam pipe. The threading on the pipe has to be accurately and properly done; the joints must butt in the couplings and the threads on the pipe should not extend beyond the threads in the coupling. A sleeve coupling which extends beyond the threads on the pipe is very efficient and should be used, as it will save much pipe from breaking in the threads and being lost together with the hole.

All drills were mounted on scows 14 feet wide and 40 feet long. These scows were decked, and a slot about 18 inches wide and 7

feet long was cut back from the butting beam extending through the bottom and deck of the scow and also through the butting beam itself. The drill worked through this slot. A well through the scow under the drill might answer, but it would not permit of the boats being moved from over the hole without the pulling of the drive pipe: this would lose the hole if it were not completed. Spuds with hand-power hoists were provided to hold the boat in position; anchors and lines were also provided for getting the boats into approximate position; pike poles are also very necessary. In high wind and swift water all of these things proved useful, especially when the crews were inexperienced river men.

The majority of the holes were driven in positions where a barge could be floated over the hole; however, in many cases it was not possible to do this. In these cases an A-frame of 4 by 4 inch timbers was placed over the position of the hole to support the drilling tools and the drilling line was led from the machine on the barge to the string of tools by means of three sheaves, one on the head of the barge, one at the foot of the A-frame and one at its head. The distance from barge to A-frame was in some cases as much as 300 feet. In such cases the effectiveness of the ''spudding'' device was greatly diminished by the slack and whip of the line. Of course, coring could not be done in such a manner, as the machine itself would have had to be placed directly over the hole. Fortunately, the uniformity of the formation, as proved by the witness of many holes nearby, made it unnecessary to take cores from holes inaccessible to the coring machines.

The determination of foundation conditions by borings is often a matter requiring the best of judgment at the drill itself. Samples as they come up through the casing or drive pipe do not give a clear indication of the conditions that exist at the bottom of the hole. If a core can be taken that is in itself good evidence that the material is good enough to sustain any ordinary load and can resist erosion. If a core can not be taken, that is evidence that the material is of very doubtful character, and makes it all the more desirable that a sample be obtained which will be in the exact condition in which it existed when in its bed. If it has been pounded up into fragments by a drill or washed to pieces by a jet, then the sample is deceptive. Samples of soft shale were obtained by driving the drive-pipe into the shale and pulling the sample out in the pipe; a better and surer method is to drive a smaller piece of pipe inside the regular drive pipe; other soft

materials can be taken out in a similar manner, though it is difficult to hold fine sand and gravel in a pipe or in the end of a special split-steel cylinder made on the order of a post-hole digger. This device was made in the form of a bit attached to the regular drill rods; it should have been fastened to the end of a piece of drive pipe of smaller diameter than the regular drive pipe, so that it could have been placed inside the latter and have been struck heavy blows by the drive-weight.

An experienced drill operator can tell the character of the materials through which his drill is passing, but the engineer must see the material in the form of a core or an unmodified sample. Observations on the driving of the drive-pipe give a method of arriving at the approximate bearing power of piles for pile foundations. Such observations were not made on this survey, but should have been.

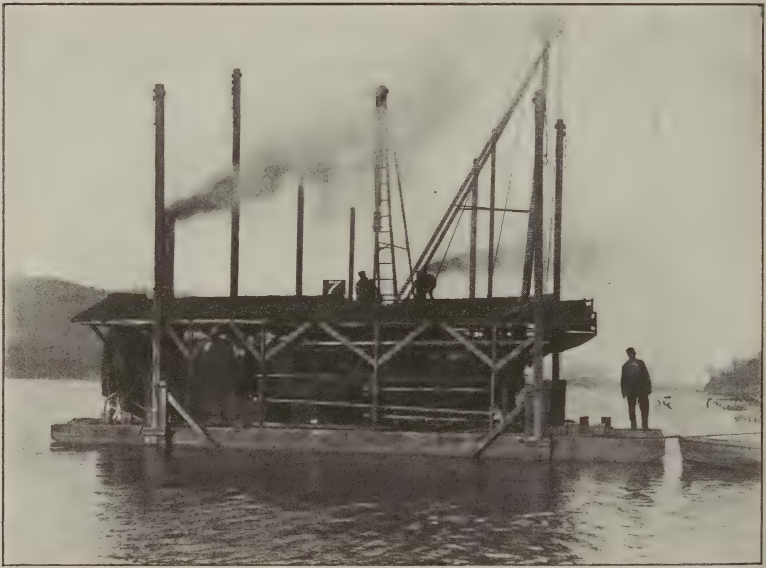


Fig. 2. Cyclone Drill Boat

A boulder formation has in many instances caused misconceptions as to rock for foundations. The avoidance of such errors rests in the drilling of a sufficient number of holes and in sending them all several feet into the rock when struck.

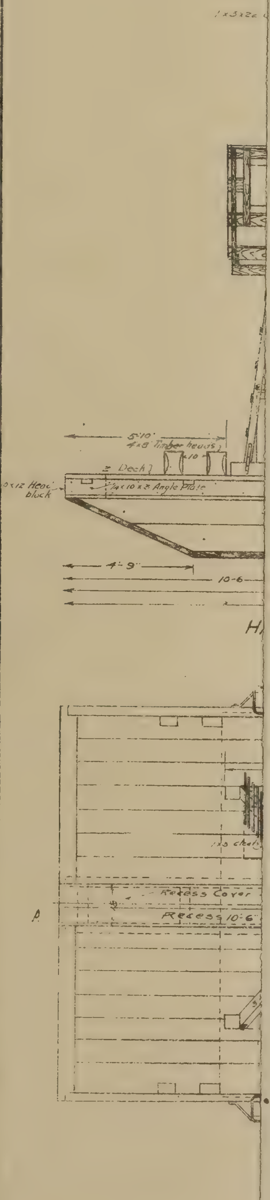
In determining the number of drills to be operated it was endeavored to have such a number as would enable the drill party

War Department

PAINTS & OILS

125-lbs.		Red Lead
7	Gallons	Linseed oil
½	Pint	Japan dryers
	bales	"Best" oakum
	bbls	Pitch
	lbs.	Spun cotton
	"	Salt.
25	"	Oxide of iron
1½	Gallons	Linseed oil
¼	Pint	Japan dryers.

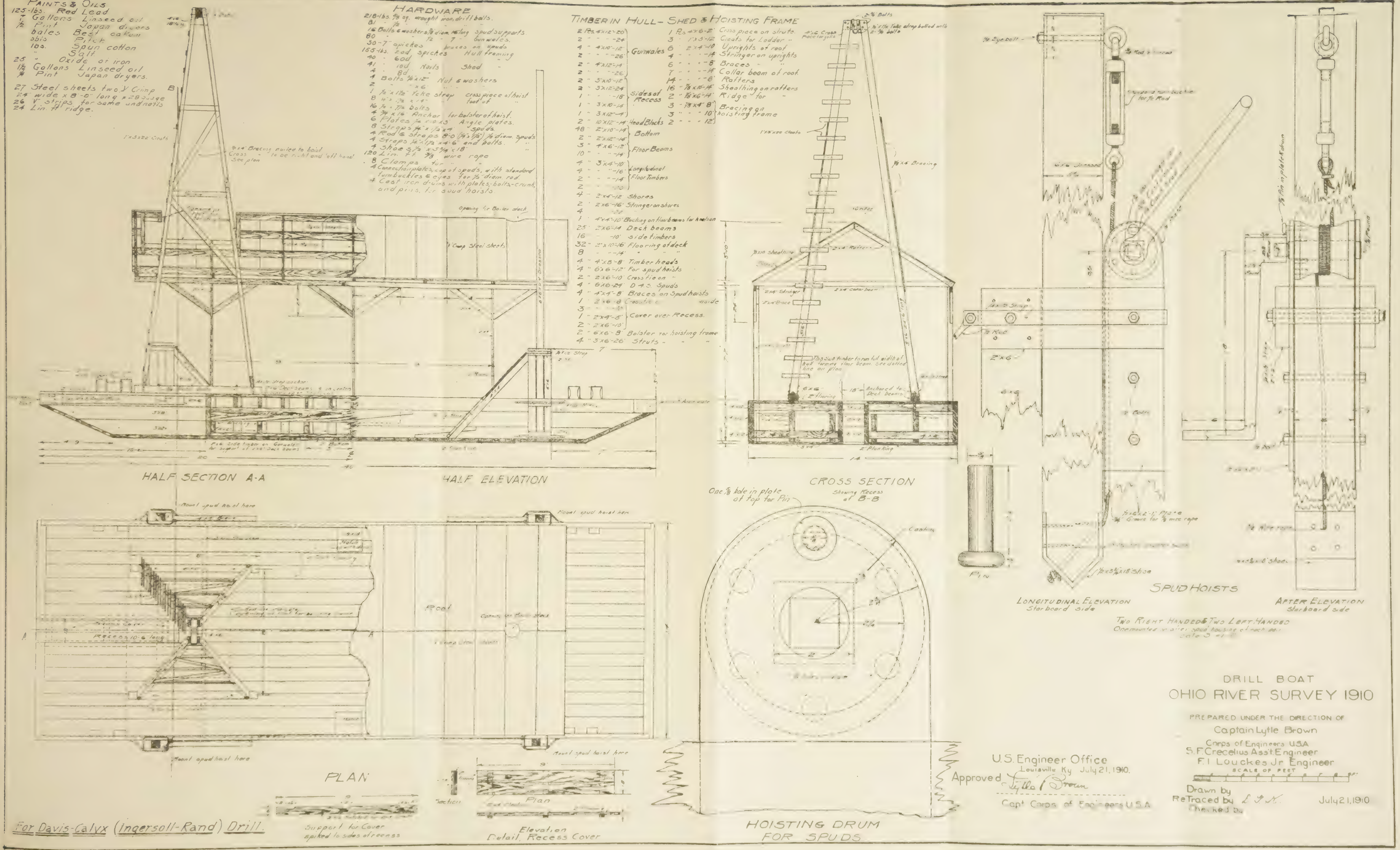
27 Steel sheets two "V" Crimp
24" wide x 8'-0" long. #28 gu
26 "V" strips for same and na
24 Lin. ft. ridge.



For Davis-Calyx (Inge

War Department

Corps of Engineer U.S.A



PAINTS & OILS

125-lbs. Red Lead
7 Gallons Linseed oil
½ Pint Japan dryers
bales Best oakum
bbls Pitch
lbs. Spun cotton
" Salt
25 " Oxide of iron
1½ Gallons Linseed oil
¼ Pint Japan dryers.

27 Steel sheets two V Crimp 24" wide x 8'-0" long x 28 gauge
26 V strips for same and nails
24 Lin. ft ridge.

HARDWARE

218-lbs. ⅝ sq. wrought iron drill bolts.
81 " ½ " " " "
16 Bolts & washers ⅝ diam. 16 long spud supports.
80 " " ½ " 7" Gunwales.
30-7" spickes braces on spuds
155-lbs. 20d spickes Hull framing
40 " 60d " "
41 " 10d Nails Shed "
4 " 8d "
4 Bolts ¾x12" Nut & washers
2 " " x6 " "
1 ½"x1½" Yoke strap cross piece of hoist
8 4"x1½x14" " foot of "
16 ½x7½ bolts
4 ¾x16" Anchor for bolster of hoist.
6 Plates ½x10x3" Angle plates.
8 Straps ¼"x1½"x4" spuds.
4 Rod & straps 8'-0 (¼"x1½") ½" diam. spuds
4 Straps ¼"x1½ x4'-6" and bolts. "
4 Shoe 5½"x5¾x18" "
120 Lin. ft. ⅞ wire rope
8 Clamps for " "
4 Connection plates, cap of spuds, with standard turnbuckles & eyes for ½" diam. rod.
4 Cast iron drums with plates, bolts, crank, and pins, for spud hoists.

TIMBER IN HULL – SHED & HOISTING FRAME

2 Pcs 4"x12"-20' Gunwales
2 " " " -24'
4 " 4"x10"-12'
2 " " " -26'
2 " 4"x12"-14'
2 " " " -26'
2 " 3"x10"-12' Sides of Recess
2 " 3"x12"-24'
1 " " " -18'
1 " 3"x10"-14'
1 " 3"x12"-4'
2 " 10"x12"-14' Head Blocks
48 " 2"x10"-14' Bottom
2 " 2"x12"-14'
3 " 4"x6"-12' Floor Beams
10 " " " -14'
4 " 3"x4"-10' Longitudinal Floor Timbers
4 " " " -16'
2 " " " -14'
2 " " " -20
4 " 2"x4"-12' Shores
2 " 2"x6"-16' Stringer on shores
4 " -22 "
1 " 4"x4"-10' Blocking on floor beams for keelson
25 " 2"x6"-14 Deck beams
16 " -10' side timbers
32 " 2"x10"-16' Flooring of deck
8 " " -14' " " "
4 " 4"x8"-8' Timber heads
4 " 6"x6"-12' For spud hoists
2 " 2"x6"-10' Cross tie on "
4 " 6"x6-24' D.4.S. Spuds
4 " 4"x4"-8' Braces on Spud hoists
1 " 2"x6"-8' Cross tie [illegible] inside
3 " " " -10' Cover over Recess.
1 " 2"x4"-5'
2 " 2"x6"-10'
2 " 6"x6"-8' Bolster for hoisting frame
4 " 3"x6"-26' Struts " " "

1 Pcs 4"x6"-2' Cross piece on struts.
3 " 1"x3"-12 Cleats for Ladder "
6 " 2"x4"-10 Uprights of roof
4 " " " -14' Stringer on uprights
6 " " " -8' Braces " "
7 " " " -14' Collar beam of roof.
14 " " " -8' Rafters
16 " ⅞"x10"-14' Sheathing on rafters
2 " ⅞"x6"-14' Ridge for "
3 " ⅞"x4" 8' Bracing on hoisting frame
3 " " " 10'
2 " " " 12'

DRILL BOAT
OHIO RIVER SURVEY 1910

PREPARED UNDER THE DIRECTION OF
Captain Lytle Brown
Corps of Engineers U.S.A
S. F. Crecelius Ass't. Engineer
F. I. Louckes Jr Engineer

SCALE OF FEET

U.S. Engineer Office
Louisville Ky July 21, 1910.
Approved Lytle Brown
Capt Corps of Engineers U.S.A

Drawn by
ReTraced by L. F. N. July 21, 1910
Checked by

For Davis-Calyx (Ingersoll-Rand) Drill.

PAINTS & OILS

125-lbs. Red Lead
7 Gallons Linseedoil
½ Pint Japan dryers
bales "Best" Oakum
bbls. Pitch
lbs Spun Cotton
" Salt.
30 " Oxide of iron
2 Gallons Linseed oil
¼ Pint Japan dryers.

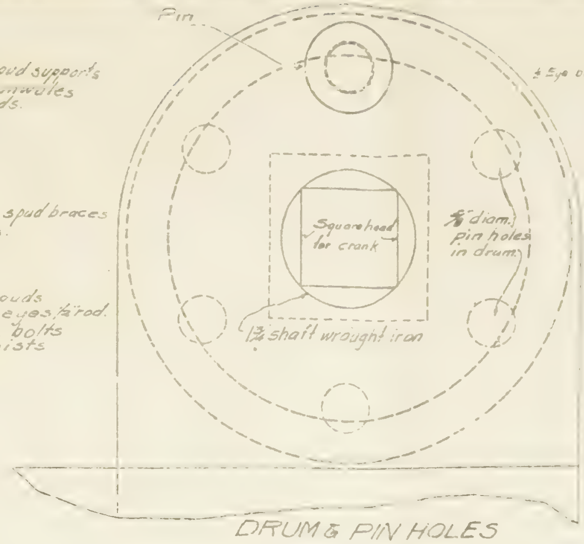
20 Steel sheets two "V" crimp 24" wide x 7' long #28 guage
14 24" x 5' " "
18 "V" strips and nails 7'
14 " " " " 5'
20 Lin. ft. ridge.

TIMBER IN HULL-HOISTING FRAME & SHED

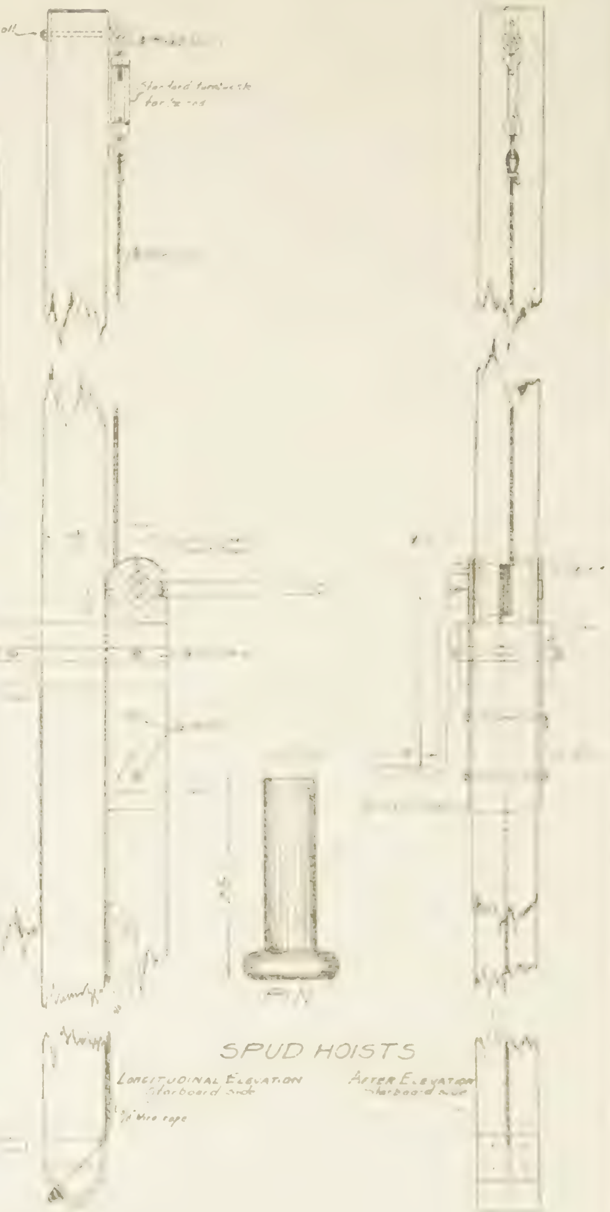
2 Pcs.	4"x12"-20'	Gunwales
2 "	" " -24'	
4 "	4"x10"-12'	
2 "	" " -26'	
2 "	4"x12"-14'	
2 "	" " -26'	
1 "	3"x10"-14'	Sides of Recess
2 "	" " -20	
1 "	" " -10	
2 "	10"x12"-14'	Head Block
48 "	2"x10"-14'	Bottom
2 "	2"x12"-14'	
1 "	4"x6"-12'	Bottom beam
10 "	" " -14'	
4 "	3"x4"-10'	Longitudinal floor timber
4 "	" " -16'	
2 "	" " -14'	
2 "	" " -20'	
4 "	2"x4"-12'	Shores
2 "	2"x6"-18'	Stringer on shores
4 "	" " -22'	" " "
1 "	4"x4"-10'	Blocking on bottom beam for keelson
25 "	2"x6"-14'	Deck beams
16 "	" " -10'	Side timbers
32 "	2"x10"-16'	Flooring of deck
8 "	" " -14'	" " "
4 Pcs.	4"x8"-8'	Timber heads
4 "	6"x6"-12'	For spud hoists
2 "	2"x6"-10'	Cross tie on spud "
4 "	6"x6"-24'	D.4.S. Spuds
4 "	4"x4"-8'	Braces on " hoists
1 "	2"x6"-8'	Cross tie on " " inside
3 "	2"x6"-8'	Cover on Recess
1 "	2"x4"-4'	
2 "	2"x6"-8'	
9 "	2"x4"-10'	Upwrights
4 "	" " -8'	"
14 "	" " -8'	Braces
2 "	" " -12'	Stringer
2 "	" " -16'	
2 "	" " -8'	
2 "	" " -14'	
16 "	" " -8'	Rafters
5 "	" " -10'	"
10 "	7/8"x4"-16'	Sheathing
12 "	" " -20'	"

HARDWARE

218-lbs. 5/8" sq. wrought iron drift bolts
81- " ½" " " " "
16 Bolts & washers ⅞" diam. 16" long. spud supports
20 " " ½" " 7" " Gunwales
30- 7" spikes braces on spuds.
155-lbs. 20d. " Hull framing
40 " 60d. " "
60 " 10d. Nails Shed "
15 " 8d. " " "
6 Angle plates ¼"x10"x5"
8 Straps ¼"x1½"x4' spuds.
4 Rod & straps 8'-0" (¼"x1½") ½" diam. spud braces
4 Straps ¼"x1½"x4'-6" with bolts.
4 Shoes ½"x 5¾"x 18"
120 Lin. ft. 3/8" wire rope
8 Clamps for " "
4 Connection plates at cap of spuds with standard turnbuckles & eyes, ½" rod.
4 Cast iron drums, with plates, bolts crank and pins for spud hoists



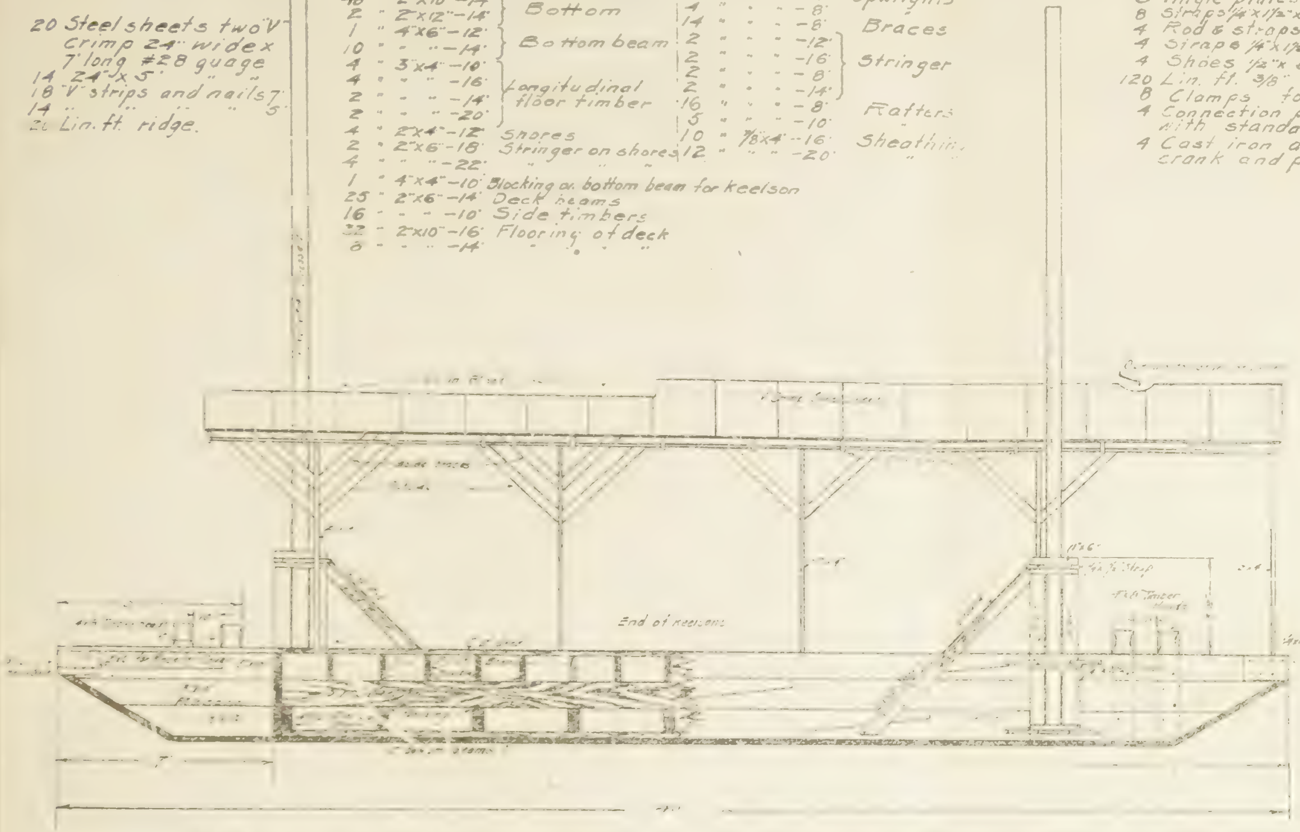
DRUM & PIN HOLES



SPUD HOISTS

LONGITUDINAL ELEVATION Starboard side

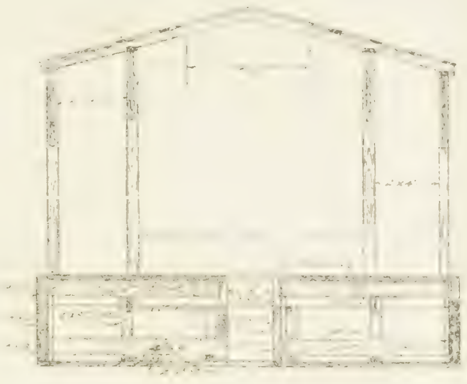
AFTER ELEVATION Starboard side



ONE HALF LONGITUDINAL SECTION

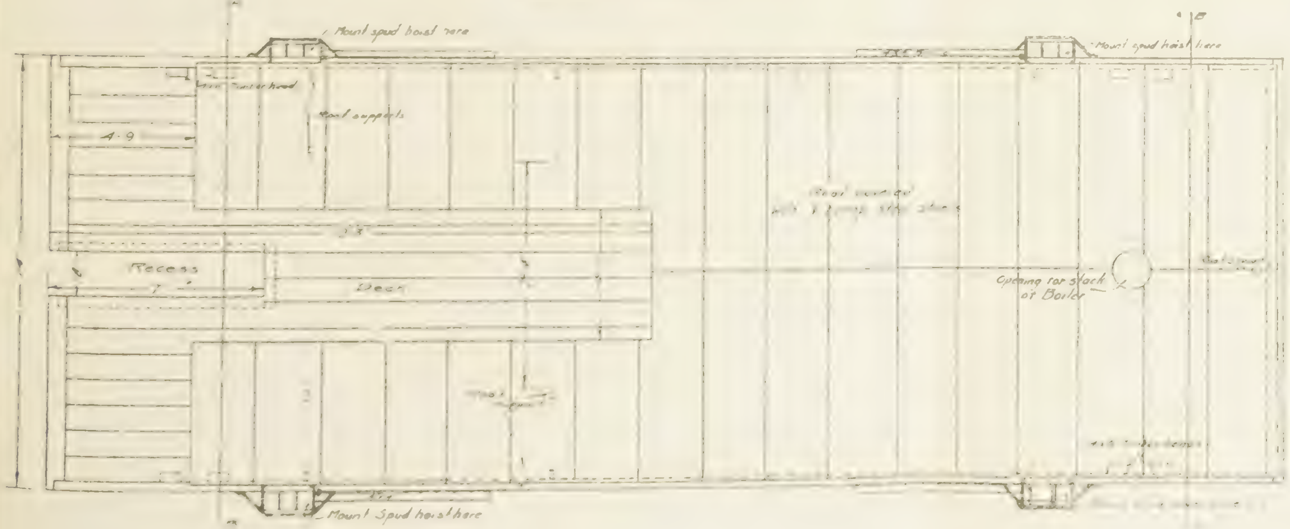
ONE HALF LONGITUDINAL ELEVATION

Elevation of full length of Shed



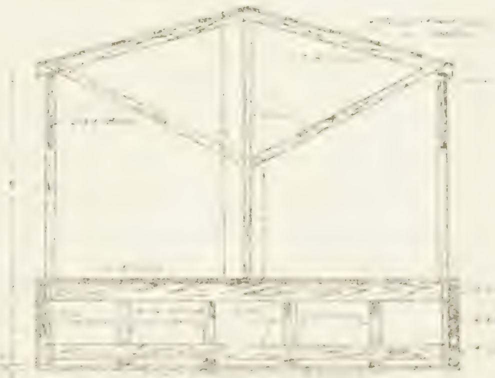
CROSS SECTION

showing recess at A-B



PLAN

Showing deck & roof



CROSS SECTION of HULL

& Rear End Elevation of Shed at B-C

For Cyclone Drill

U.S. Engineer Office
Louisville Ky July 23 1910
Approved Lytle Brown
Capt. Corps of Engineers USA.

DRILL BOAT
OHIO RIVER SURVEY 1910

PREPARED UNDER THE DIRECTION OF
Captain Lytle Brown
Corps of Engineers U.S.A.
[illegible] Asst. [illegible]
[illegible] Jr. Engineer
SCALE OF FEET
Drawn by
Re-Traced by [illegible] July 23
Checked by.

to keep pace with the survey party, in order that all data might be available for any site at the same time, and that parties should be bunched for the best supervision and administration. Practically, it was not always possible to keep the two parties abreast; in the second season's work this was more nearly done than in the first. Separate organization of the two parties, drill and survey, was necessary in the first season, but in the second season the chief of the survey party was also chief of the drill party and supervised both. One drill and one survey party were used the first season; in the second season two drill and two survey parties were used.

Fig. 3. Cyclone Drills Working on Shore Holes, Site No. 42

The drill party had the following organization:

1 chief of party.
1 drill foreman.
1 clerk (timekeeper, subsistence clerk and property man).
1 instrument man (locating holes).
2 skiff men.
1 night watchman.
1 cook.
2 cook's helpers (waiters and quarter boat police).
6 drill crews: 1 recorder, 1 engine man, 1 fireman, 1 laborer.
1 steamboat crew: 1 pilot, 1 engineer, 1 fireman, 1 deckhand.

The general equipment of the party was:

1 quarter boat, 6 drill boats: 2 with Ingersoll-Rand core drills, 4 with Cyclone spudding drills.
1 steamboat (for placing drills, and general towing of the entire outfit).
1 full flat, 8 skiffs.

The steamboat should have enough power to handle the whole outfit, but should be a quick and good handler for placing single boats. A boat of about 20 by 100 feet, with 10-inch cylinders and 4-foot stroke should be good. The boats used had a little less power.

A complete outfit for one Ingersoll-Rand drill consisted of:

One "G4" rotary drill for drilling 3¼-inch holes and cutting 2⅜-inch cores; with sensitive feed, speed changing device for driving either Davis cutters or shot bits at proper speed, and hinges for swinging drill aside for driving pipe. Cut gears and bronze bushings throughout.

One No. 1 friction drum hoist with foot lever, brake, ratchet and pawl and winch head.

One 5 hp. vertical steam engine, single cylinder, with governor, sight feed lubricators, drain cocks, oil cups, throttle valve and wrenches. Drill hoist and engine mounted on substantial wooden frame with the necessary belt sprockets and chain, for connecting engine with drill and hoist.

One 8 hp. vertical boiler, with smokestack, grate, pop safety valve, steam gauge, gauge cocks, injector, and cast-iron boiler base.

One Canton, duplex steam pump, 4½-inch steam and 3-inch water cylinder, 4-inch stroke, with grout cock, foot valve, and strainer.

1 water swivel.
2 hoisting swivels.
4 Davis cutters.
1 supporting fork.
1 drive weight and jars.
50 pounds groat.
2 fishing taps.
1 shot feed.
1 spanner wrench.
4 shot bits.
4 chopping bits.
1 pair casing clamps.
1 safety shackles.
1 drill spindle.
1 cone barrel, 8 feet.
1 cone barrel, 4 feet.
1 cone barrel, 2 feet.
200 pounds chilled shot.
1 socket wrench.
5 drill rods, 18 inches long.
2 drill rods, 5 feet long.
4 drill rods, 10 feet long.
1 set matched couplings.
1 pressure rope.
1 gouge.
1 flatter.
1 dressing plate.
1 10-inch steel pulley.
75 feet ⅜-inch wire line.
150 feet 1 inch manila line.
1 triple block, 1 inch line.
1 double block, 1 inch line.
1 anvil.
1 combination vise.
1 forge.
1 hot chisel.
1 cold chisel.
1 pair Smith's tongs.
1 hammer bale bean.
1 monkey wrench, 12 inch.
1 Stillson wrench, 24 inch.
2 chain pipe wrenches, No. 13.
6 10-foot lengths XX drive-well pipe and couplings.
6 5-foot lengths XX drive-well pipe and couplings.
5 2-foot lengths XX drive-well pipe and couplings
1 3½-inch drive head (steel).
2 3½-inch drive shoes (steel).
1 firing hoe.
1 slicer.
1 flue cleaner.
1 shovel.
10 feet hose for shot feed.
15 feet hose for water swivel.

And the necessary piping for water and steam connections.

Fig. 4. Shore Hole "A" Frame at Site No. 42, for boring holes on shore, using drill boat to operate drill

When the force was increased for the 1910 season "F" machines were bought instead of the "G4;" these are heavier machines and better adapted to the rough work to which they were subjected. These machines were provided with a special spudding device which proved to be of little value.

A complete outfit for one Cyclone drill consisted in the following:

1 No. 4 steam drill fitted with Cyclone positive clutch, mounted with engine on three sills.
1 7-hp. vertical engine.
1 27-ft. A-frame with crown and sand line pulleys.
1 12-hp. vertical boiler on cast-iron base.
1 Canton duplex pump, 5½-inch steam cylinder, 3½-inch water cylinder, 5-inch stroke with fittings and connections.
60 feet of 2-inch XX, and 1½-inch XX drill rods.
120 feet 3½-inch XX drive-well pipe in 5 and 10-foot lengths, with couplings.
1 drill head.
2 drive shoes.
1 300-pound drive-weight, with wrenches.
1 pair drill handles.
2 No. 12 Vulcan tongs.
1 grab hook.
1 smith's hammer.
1 3-inch bit gauge.
1 cold chisel.
1 14-inch file.
1 handsaw.
1 axe.
1 rope hook.
1 rope bolt.
150 feet 1½-inch mill hose for shore drilling.
1 jetting head.
1 set steel drive clamps.
2 3-inch rock bits.
1 driver stem.
1 driver stem eye.
2 tool wrenches.
1 foot wrench.
1 1½-inch taper taps.
1 oil can.
1 belt punch.
1 20-foot length 1½-inch armored hose.
1 suction pipe and pump strainer.
1 ball-bearing packing box and stem, with swivel.
18 feet discharge hose.
1 14-inch monkey wrench.

The unit costs of the work was kept in detail, and for the season of 1909 were as follows, per linear foot:

Wash borings, preliminary set: Labor, 0.278; subsistence, 0.098; fuel, oil, etc., 0.041; repairs, 0.034; towing, lost time, etc., 0.485; total, 0.936.

Wash borings, final set: Labor, 0.201; subsistence, 0 102; fuel, oil, etc., 0.051; repairs, 0.036; towing, lost time, etc., 0.566; total, 0.956.

Core borings, final set: Labor, 0.628; subsistence, 0.262; fuel, oil, etc., 0.146; repairs, 0.101; towing, lost time, etc., 1.540; total, 2.677.

The governing item in these costs seems to be that of towing, lost time, etc. This is due to the special conditions of the case. The moving of the outfit, especially upstream, was very expensive, owing to the great difficulty of navigation on the Upper Ohio at the low stages of the river. While the party and outfit was being slowly pushed upstream expenses were not reduced, but augmented, and no work was done. In any case where no great moving has to be

done, the cost of the work can be materially reduced from the figures given above. Had a contractor taken this work he would have been most likely to have fallen down on the item of lost time due to moving and the cost of towing.

THE PARIS HARBOR PROJECT

A remarkable study has recently been made by "La Technique Moderne" on the Brussels harbor work. Already Berlin and Rome, to speak only of the great capitals which are not naturally connected with the sea, have tried to establish this communication by waterways; the works are at present under construction and will be completed in a few years. Paris alone, a commercial and industrial metropolis, has not attempted to utilize the beautiful waterway between Paris and the sea, formed by the Seine.

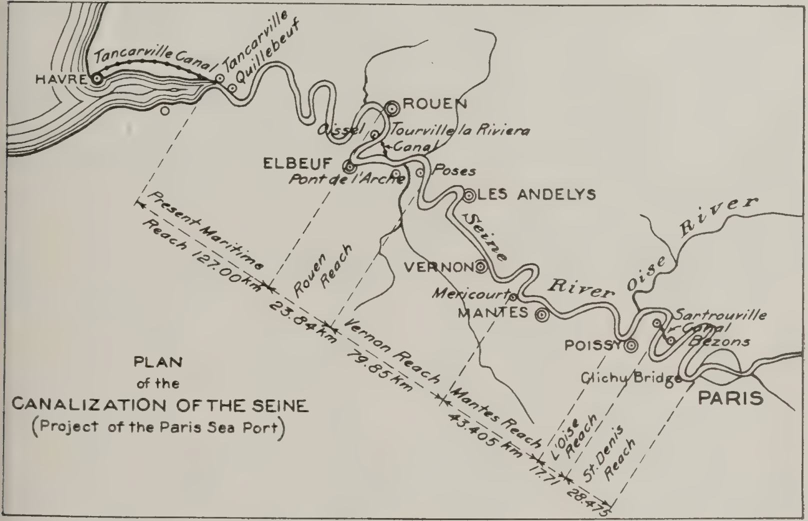
Nevertheless, by its situation, Paris is better placed than London, Antwerp, Rotterdam, or Hamburg to form a port of European commerce and the center of world exchange. Doubtless the 200 kilometers, which separate it from the English channel, will never allow it to become a port for travellers, but the commerce is more interesting from a commercial and industrial view. At present, this traffic, already exceeding three million tons a year, is limited by the insufficient and precarious means of transport. Thus, in the last quarter of 1910, a strike of some days on the railways, followed by the stoppage of the transfer by boats on account of the great floods, greatly disturbed the economic life of all the region of northern and eastern France. Boats not being able to unload at Havre and at Rouen, shops and mills in the east shut down on account of the lack of raw materials (cotton, etc.), and the very important traffic in fuel was also affected; such are the consequences of a situation which nothing will prevent from recurring frequently.

Thus the construction of the Paris harbor becomes a great necessity. The technical study of the project was set forth thirty years ago by M. Bouguet de la Grye, engineer and chief of the hydrographic service. The request for concession and the bill declaring the work of public utility was introduced in 1886 by Admiral Thomasset; since then the question has not been pushed.

The project looks to the canalization of the Seine from the bridge of Chichy, near Paris, to Rouen (see map). The stretch from Rouen to the sea, 127 kilometers, is really considered as

navigable, since it is subject to tides, and affords to the wharves at Rouen a low water depth of 5.50 meters. From Paris to Rouen, the present navigable channel, which is 250 kilometers long, is divided into eight sections, whose depth is 3 meters. The Bouquet project includes two "cut-offs" in the Seine, which will not only shorten the distance 65 kilometers, but will avoid crossing the railway from Paris to Rouen. The first of these "cut-offs" is near Paris, from Bezons to Sartrouville; the second, above Rouen, from the Arch Bridge to Tourville, near Oissel.

The course from Paris to Rouen is not more than 186.28 kilometers, divided into five reaches. From the Bridge of Chichy to Sartrouville, 21.475 meters; from Sartrouville to Poissy, 17.710 meters; from Poissy to Méricourt, 43.405 meters; from Méricourt to Poses, 79.850 meters; from Poses to Rouen, 23.840 meters.



The depth of water sought is 7.2 meters, necessitating a mean deepening of the bed of the Seine of more than 4 meters. The width of the canal will be 35 meters at the bottom in straight reaches and 45 meters in the curves, with a radius less than 1500 meters.

The locks, four in number, will be 160 meters long and 30 meters wide. They overcome, with the slope of the pools, a total fall of 22 meters, and will have the following lifts:

Lock of Sartrouville, 3.20 meters; lock of Poissy, 4.25 meters; lock of Méricourt, 6.28 meters; lock of Poses, 6.31 meters.

As to the port of Paris, it will be created between the Bridge of Chichy and the docks of Saint-Ouen, in the center of the greatest manufacturing district of the suburbs. Five intermediate ports will be built, at Argenteuil, Poissy, Mantes, Vernon, and Andelys. Among the twenty-four bridges rebuilt on the course of the canal, the road bridges will be changed into drawbridges, and the railway bridges will have their bottom girders raised to 22.50 meters above water level.

The amount of material to be excavated is 40,500,000 cubic meters, 10,500,000 for the two cuts from Bezons and the Arch Bridge and other dry cuts, and 30,000,000 cubic meters for the dredging. The maximum cost will be 250,000,000 francs, and it is estimated, if the excavators and dredges now on hand are used, the work can be completed in six years.

As was shown in the construction of the Brussels Canal, a like enterprise can be conducted without interfering or even delaying the river traffic. The locks in themselves do not present any special difficulties, and will be easily constructed by means of cofferdams and compressed-air caissons.

As to the financial side of the project, it appears so pleasing that a company has been organized to do the work and to operate the canal without subsidy or guaranty of interest, provided they are allowed to charge a toll of 2 francs per ton. The traffic is computed to attain from 9,000,000 to 10,000,000 tons per year, a figure that apears admissible in view of the consumption of Paris itself, and existing traffic. Moreover, the municipal council of Paris has just reserved the concession of that enterprise for the city of Paris. Here, also, the example of Brussels has shown that that solution was perfectly feasible, by means of the cooperation of commune and department interests.

It is necessary to further bear in mind, and this consideration is to-day of a primary interest, that the execution of the Paris harbor project, in deepening the bed of the river below Paris and in increasing the capacity by filling the canal, will be the certain solution of a grave problem that the late Parisian floods have presented. The flood commission, in the report of its president, M. Picard, has placed of first importance the deepening of the Seine between Suresnes and Bongival. This work, of which the result will appear small beside that which will assure the maritime canal, will cost in itself thirty million francs. That cost will also be more difficult to secure, as it is destined to be totally unproductive.

Finally, the cost of maintenance of the Seine, which at present increases the budget of the state for an annual sum of 480,000 francs, will be saved, for the owners should naturally assume the maintenance of the work.

The only oppositions which would have been raised against the Paris harbor project are those of Havre and Rouen and the Western Railway, but these last are now run by the State, which is considerably discommoded in order to satisfy the needs of the Havre line, on which the traffic is very great, and which is materially interfered with at Paris and Rouen.

The example of all the great works increasing the insufficient means of transport, allows it to be said that the traffic which can be momentarily taken away at Havre, Rouen, and on the railway, will be rapidly reestablished, following the commercial and manufacturing development which the Paris harbor ought to bring forth. It is therefore apropos to hope that, in the national interest, the authorities will accept a project which awaits only their authorization to be built, whether by the city of Paris or by a private company. It will cost nothing on the budget, and the neighborhood of Paris will be delivered from the perils of inundation in addition to receiving a wonderful means for its commercial development.

THE BRUSSELS SHIP CANAL*

The capital of Belgium, a manufacturing city of about 626,000 inhabitants, is situated at a distance of 27.3 miles from Antwerp, a large seaport through which passes the greater part of the Belgian foreign trade.

The inner harbor of Brussels has for forty years been connected with Antwerp and the North Sea by the Willebroeck canal leading from Brussels to the Rupel, a tributary of the Scheldt. The canal is 91,950 feet in length, and has a depth of 10.5 feet. Its width is 49.3 feet at the bottom and 108.2 feet at the water surface and five locks are required in its course.

The harbor of Brussels, which is made up of five basins having a total area of 53,819.3 square yards, possesses wharves 8,690 feet in length. Floating bridges laid with railroad tracks have been successively built between Brussels and Laeken to care for the increased traffic through the canal, which has risen from 1,400,000 tons in 1895 to about 4,000,000 tons in 1905.

Various regular steamship lines, sailing chiefly for London, have made use of this canal for years, but the fact that the draft of their vessels is limited to 10.3 feet has proved to be a serious obstacle to the extension of this maritime service, so essential to the manufacturing and commercial development of Brussels.

For the purpose of bettering this condition of affairs and of making Brussels a seaport, plans for widening and deepening the canal were approved by the Belgian government in 1895, 1897, and 1902. A joint stock company, of which the incorporators are the general government, the province of Brabant, the city of Brussels, its neighboring towns (namely, Molenbeek-St. Jean, Schaerbeek, Saint-Gilles, Anderlecht, Laeken, Saint-Josse-ten-Noode, Ixelles, Koekelberg, and Etterbeek) and the city of Vilvorde, was formed in 1896 for a period of ninety years.

This company had for its purposes:

1. The taking over of the canal and all its appurtenances.
2. The transformation of the small canal into a ship canal.

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* Translated from the "Technique Moderne" of December, 1910, by Lieut. J. M. Wright, Corps of Engineers.

Fig. A. Plan of the Port of Brussels

1. Main ship basin
2. Lighterage basins
3. Charleroi Canal
4. Mercantile depot
5. Bridge
6. Bascule bridges
7. Outer harbor
8. National railway bridge
9. Dry dock
10. Diversion of Little Senne River
11. Depot of Schaerbeek

3. The construction of a harbor with all of its accompanying features, namely: slips, depots, basins, wharves, storehouses, elevators, sheds, cranes, etc.

4. The operation of the canal and harbor and their accessories.

5. The operation of the basins owned by the city of Brussels.

The company has taken charge of the canal and of the operation of the basins as well as of the warehouses and buildings of the port. It has begun the work necessary to the rebuilding of the canal and the construction of the seaport.

This incorporation of an industrial and commercial company in which governmental agencies are the only partners is an unusual step, the results of which it will be very interesting to trace. As it does away with the obstacles and criticisms attending a monopoly or a company operated by the government, and at the same time possesses the strength and has the facilities required for carrying out extensive schemes, such an organization seems to be well adapted for undertaking works of national interest and large extent (such as ports, canals, railroads, waterpower projects, etc.).

The dividends, or interest guarantees, which often become in reality premiums for higher bids, are here replaced by a kind of industrial loan, which yields good returns and whose control and management remains in the hands of the stockholders. The capitalization of the Association for the Maritime Improvement of Brussels, which was at first fixed at $6,480,940.00, has been increased to $9,781,240.00, and is composed of shares of the minimum value of $9,650.00. Of this sum $4,728,500.00 were subscribed by the Belgian government, $868,500.00 by the province of Brabant, $3,184,500.00 by the city of Brussels, and the remainder by the other participating corporations. Anticipating the raising of this capital, a number of bonds were sold by public subscription as the requirements of the work demanded.

The management of the association is delegated to a council of ten members, of whom five are designated by the general government, three by the common council of Brussels, one by the provincial council of Brabant, and one chosen from amongst the deputies of the communes. At the termination of the life of the association, the waterway and appurtenances of the canal from Brussels to the Rupel will become the property of the general government; the appurtenances of the port, warehouses, wharves, storehouses, cranes, etc., and the dry dock will belong to the city of Brussels, within its territorial limits. During the execution of the work a pro-

fessional board made up of four state officials and two officers chosen by the city of Brussels is in charge of the plans and superintendence of the undertaking. The head of the board is M. Zone, the chief engineer, to whose kindness we owe the technical features of this paper.

After its improvement, the canal is intended to accommodate coastwise trade as well as the domestic commerce now carried on. Its depth, at first placed at 18 feet, will be finally increased to 21.2 feet with a minimum bottom width of 59 feet, increasing to 82 feet at the normal cross section. The width at the surface varies from 131 feet in the narrowest parts to a normal width of 197 feet and an extreme width of from 229 to 328 feet (Fig. 3). The slopes are generally 3 to 1 and the banks are protected with masonry revetments. In the fills these revetments are replaced by stone walls extending 10.5 feet below the surface.

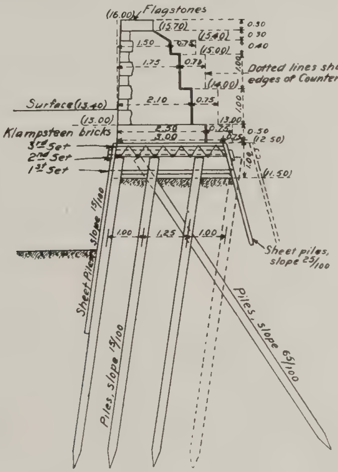

Fig B-Wall-Lighterage basin
(Dimensions in metric system)

The number of locks is reduced to three, instead of the five formerly employed. They have a useful length of 374 feet, are 52.5 feet in width and make a lift of 14.6 feet, and have 21.2 feet of water on the sills. The numerous movable bridges along the line of the canal afford an opening of 59 feet minimum width.

We shall take up in succession the most interesting technical features of this extensive work, which will, in a short time, change the Belgian capital into a seaport.

PORT OF BRUSSELS

The creation of harbor facilities for Brussels has been accompanied by the construction of a great mercantile depot on the plain of Tour-et-Taxis, west of Brussels. (Fig. A.) The main ship basin has a depth of 21.2 feet, is 2,950 feet long, and 394 feet wide, and has an area of more than 27.2 acres. Two longitudinal wharves are accessible to ships: one is 2,460 feet in available length, 174 feet in width, and has an area of 11.6 acres. The other, which is 2,950 feet in useful length, is 246 feet wide, and has an area of 17.3 acres.

The total wharfage length is 6,810 feet, of which 5,420 are available. This will accommodate, at the rate of 600 tons per meter per year, a total commerce of 990,000 tons.

The mercantile depot covers 74.1 acres and contains the custom house and a public warehouse, including sheds, offices, courtyards, etc. It has a floor area of 35,879.6 square yards. The railways from the wharves and docks are directly connected to those of the depot by two level curved tracks of 394 feet radius and one inclined curve of 361 feet radius with a grade of only .0066 per cent.

The main ship basin is joined to the Charleroi Canal by a lighterage basin 2,290 feet in length and 139.5 feet in width.

At the junction of the two basins is a bridge 131 feet wide and 39.4 feet span, with a clear height of 14.76 feet under the girders. A second lighterage basin 1,965 feet long and 114.8 feet wide is placed in the ditch of the old canal. For mercantile purposes and for the erection of warehouses, depots, etc., there has been reserved an area of 24.7 acres bordered by a new road 98.5 feet in width.

The junction with the ship canal, which is made at the entrance to the basin at the crossing of an important avenue (Avenue de la Reine) has made necessary the construction of two double bascule bridges 374 feet apart, a distance equal to the length of a lock chamber. Their single pass, 59 feet in width, is situated directly in line with the left hand draw-opening of the national railway bridge, this channel being especially reserved for ocean-going vessels. The clear height between the surface of the canal (maximum elevation 50.5 feet) and the upper part of the floor is 23.3 feet. Beyond the railroad bridge the ship canal has a projected width of 131.2 feet.

The outer harbor is 360.9 feet wide and has a depth of 21.3 feet. It will be provided on the right bank with wharves of 6,561.7 feet usable length. These docks, which are fitted with modern ma-

chinery, are bordered by a platform 360.9 feet wide, which belongs to the railroad station of Schaerbeek. The outer harbor is especially reserved for the larger coasting trade and for trans-shipments and will be made complete by the construction of dry dock for the repair of ships.

Some changes are being made in the course of the Senne River, at the approaches to the harbor structures, since the bed of this river occupies the site of the wharf for the outer harbor. The Senne is turned directly into the connecting basin through a diversion which can pass, in time of flood, 2,119 cubic feet of water (per second). The water passes through the connecting basin, the main ship basin, and the canal to Vilvorde, where it returns to the Senne through a sluice, which can also pass 2,119 cubic feet per second, with a flow 1.31 feet in depth. As a result of proceeding with this scheme, shoals of considerable extent have already formed in the connecting basin and it has been necessary to remove them by means of expensive dredging.

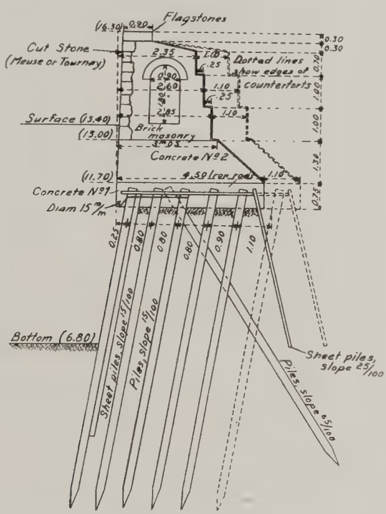

Fig. C Wall-Main Basin.

(Dimensions in metric system)

Various borings were made as a preliminary in order to learn the nature of the soil at the sites for the wharves for the diversion for the Senne, and for the warehouse and its annex. At the site of the main basin the soil is composed of three characteristic layers, which vary in thickness. The first is made up of filled ground.

the second of modern clayey deposits, the third of coarse sand and pebbles from the ancient deposits resting immediately on Ypresian clay.*

The foundation walls of the wharves and the revetment walls have been constructed by a very interesting method. Various types of these walls will be considered in detail.

For the lighterage basin the wharf wall has been designed to sustain a load of 409.6 pounds per square foot. (Fig. B.) It is built on a row of piles which are from .72 foot to .92 foot in diameter and 29.5 feet in length. They are set obliquely with a slope of 15-100. These piles are arranged in transverse rows of three each and are spaced from 3.28 to 4.1 feet in the rows, the latter being 4.92 feet apart longitudinally. A row of piles 32.8 feet in length inclined in the opposite direction with a slope of 65-100 insures resistance to sliding; a line of jointed sheet piling 0.46 foot in thickness and 18 feet in height is supported by the interior line of piles and extends about two-thirds of the distance to the surface. The exterior side of this foundation is finished by sheet piles .26 foot in thickness and 9.8 feet long.

On top of the piles is placed a sill of reinforced concrete 3.28 feet thick, into which the heads of the piles penetrate about 1.64 feet. The concrete is reinforced by three sets of metal rods. The first and lowest set consists of rods .59 inch in diameter placed transversely, there being two to each line of piles sloping to the left and two for the piles sloping to the right. The second and third sets are made of rods .59 inch and .39 inch in diameter, respectively, spaced 1.64 feet each way. These two reinforcements are joined by diagonal rods .59 inch by 1.5 inches in cross section and spaced 1.64 feet longitudinally. In addition, bolts .59 inch in diameter and 1.64 feet apart hold in place the sheet piles which protect the sides of the reinforced concrete sill.

Upon this sill a substructure, 1.64 feet thick, of selected brick (Klampsteen) extends from the foundation to the wall of the wharf proper. The latter is composed of ordinary brick masonry and is 8.86 feet high, 6.89 feet broad at the base and 4.92 feet at the top. It is faced with dressed stone averaging 1.14 feet in thickness.

The top is of granite flagstones .98 foot thick and 2.95 feet long. The wall of the wharf rises 8.69 feet above the surface and has a 4 per cent slope. It is reinforced by counterforts 2.46 feet thick.

The walls of the wharves of the main basin are designed for a

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*Ypres—a Flemish town.

load of 1,228.8 pounds per square foot and extend 9.84 feet above the surface. As shown by Fig. C, they are erected on foundations of the same nature as those just described. The piles, however, are 32.8 feet to 36.1 feet long, are set in rows of five, and are from 2.62 feet to 2.95 feet apart, while the longitudinal interval is reduced to 4.1 feet. The heads of the piles are joined in both directions by iron bars, 3.14 inches by .314 inch, fastened by spikes; the portion encased in the concrete is strengthened by a single system of rods .472 inch in diameter surrounding the inner three piles of each row. Above, a stronger sill is formed by a mass of concrete 4.27 feet high, 14.8 feet thick at the base, and 10 feet at the top. Through the mass of the wall of the wharf is cut an arched gallery 2.95 feet broad and 5.91 feet high. The thickness of the counterforts is here 3.61 feet.

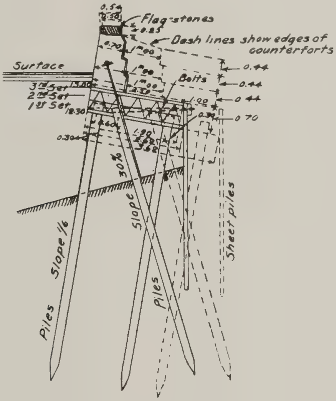


Fig D Revetment Wall Head of Lock

(Dimensions in metric system)

A similar plan has been adopted for the revetment wall upstream from the locks, which is to bear a load of 81.9 pounds per square foot. (Fig. D.) It is founded on three rows of piles 24.6 feet long, placed obliquely, two sloping to the left and the other to the right; these support a sill of reinforced concrete 2.3 feet high and 8.20 feet thick. The reinforcement consists of three inclined systems of rods of .275 inch and .59 inch diameter and of diagonal tie rods 1.57 inches by .059 inch, spaced 1.97 feet apart. The wall proper of the basin, which is about 2.62 feet thick and 4.92 feet high, is of brick masonry and is anchored to the lower sill by bolts .984 inch in diameter bearing on large iron plates 1 foot square and 1 inch

thick. For the counterforts the thickness of the masonry is increased 3.28 feet.

The cost of erecting these walls varies from $37.43 per linear foot for the type shown in Fig. B to $55.85 for the type in Fig. C, and decreases to $18.53 for Fig. D.

The ship canal proper is 18.64 miles long and is divided into three pools, which are respectively, 57,843.7 feet, 17,001.3 feet, and 23,161 feet in length. The minimum cross section has a bottom width of 82 feet, a depth of 21.3 feet, and a surface width of 187 feet. The banquettes, which are levelled off at 426 feet above the surface, are 26.2 feet thick in the fills and 29.5 feet in the cuts. Throughout the fills the width varies, but is always at least 65.6 feet at the bottom, with a depth of 21.3 feet, the surface being maintained at 10.5 feet in order to preserve the equilibrium of the revetment walls.

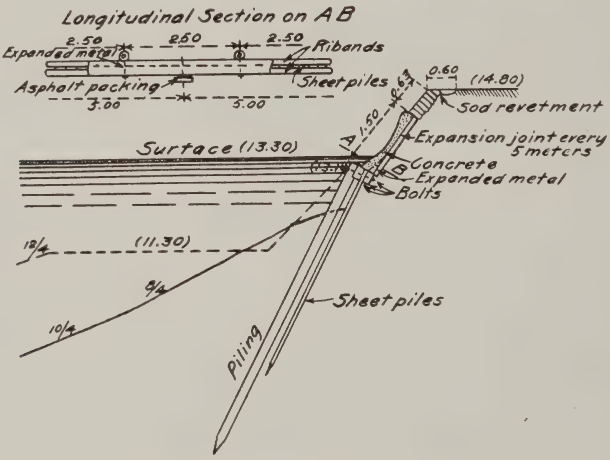


Fig. E—Bank protection.

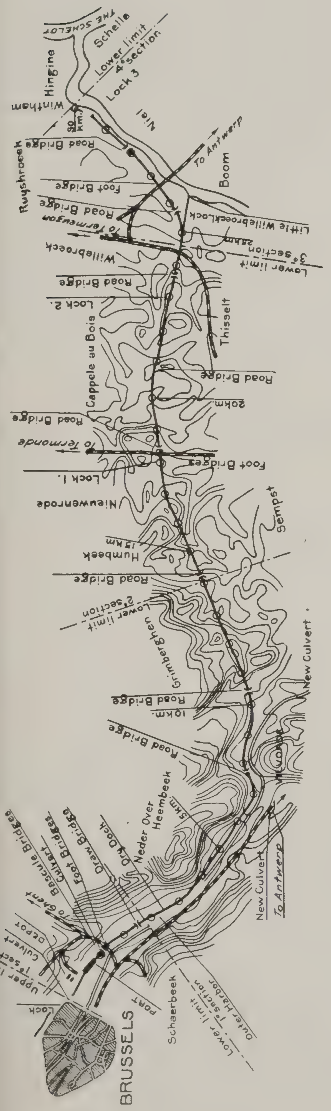
(Dimensions in metric system)

The last section of the canal, composed of a diversion 3.1 miles in length parallel to the Rupel is 262.5 feet wide at the surface and has a bottom width of 159.1 feet and depth of 21.3 feet. The banks are 26.2 feet thick with exterior slopes of 3 on 2.

As a result of the changes in the canal many culverts, which were used for the passage of streams or for drains, have had to be rebuilt.

Only one accident of importance has attended the construction of these auxiliary works. On June 3, 1909, before the new culvert

PLAN OF THE SHIP CANAL FROM BRUSSELS TO THE RUPEL



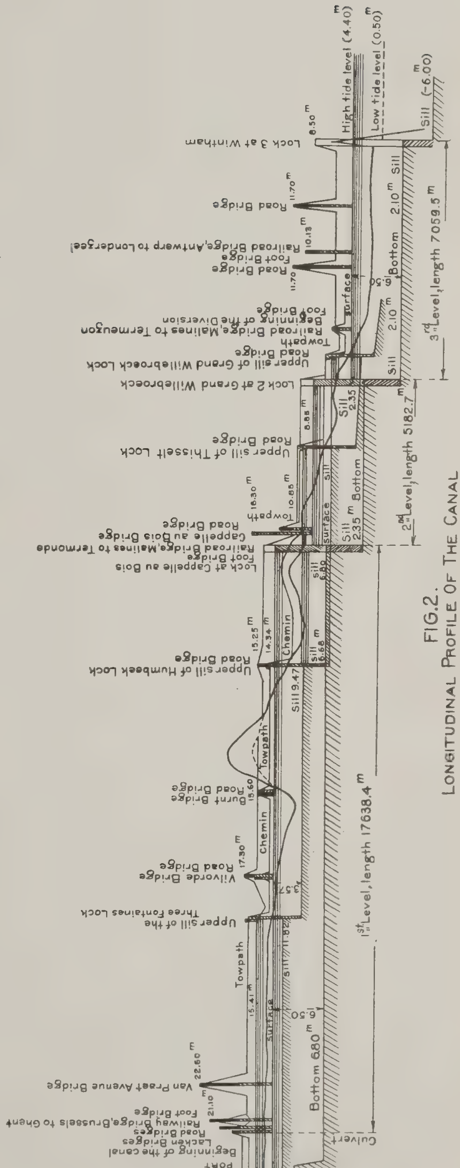
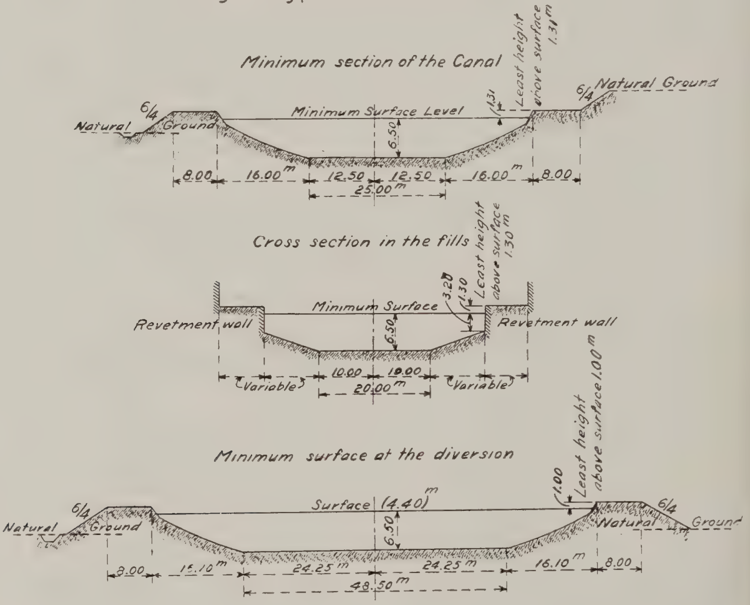


FIG. 2.
LONGITUDINAL PROFILE OF THE CANAL

with two drains for Neder-over-Heembeek had been put into service, while the contractor was occupied with work preparatory to the destruction of the culvert of Trois-Trous, the water broke through near the wall under the apron at the downstream end of the culvert, the wall crumbled, and the water of the canal flowed into the Senne. The surface of the water in the first level fell 8.79 feet in twelve hours. This lowering caused slides in the banks, especially between Neder-over-Heembeek and Trois-Fontaines. On the other hand, the walls of the wharves and the basin stood firm and did not slide.

Fig. 3. Typical cross sections of the Canal



The consequence of the accident was a period of three weeks of idleness for the vessels moored in the basins. The association immediately constructed three cofferdams, isolating the old culvert, and dug a temporary passage at the side of the crumbled work. The level was then refilled with water up to the former height (50.5 feet), and regular navigation was resumed on the 19th of June.

Pumps were also provided to discharge into the canal the water from the branch culverts, which, before the accident, passed through the culvert of Trois-Trous. This permitted the destruction of that culvert.

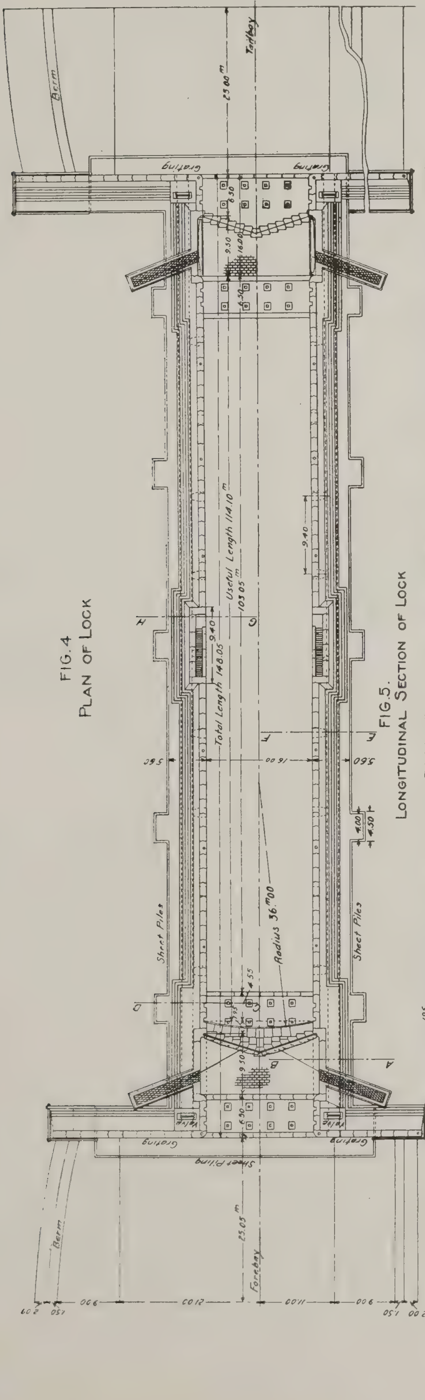


FIG. 4
PLAN OF LOCK

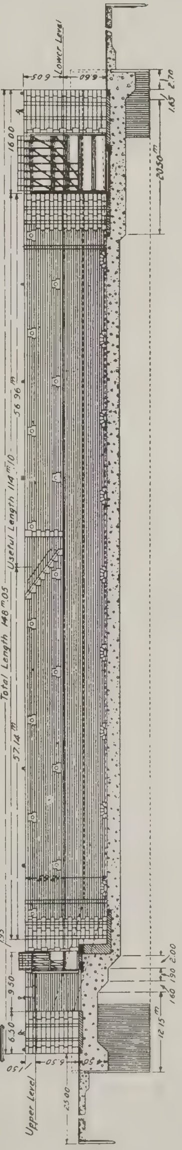
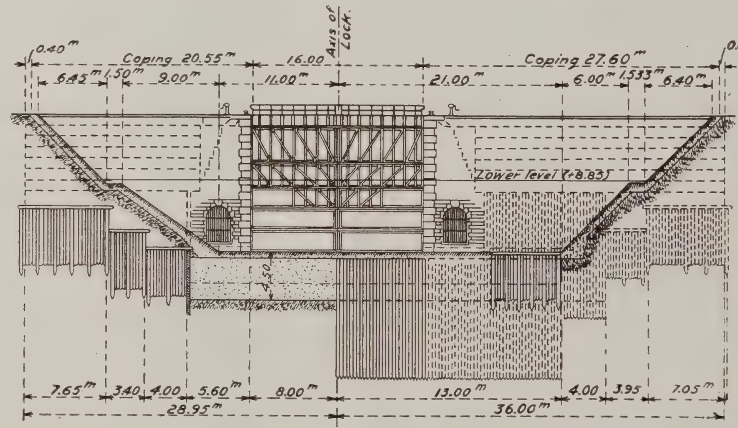


FIG. 5.
LONGITUDINAL SECTION OF LOCK

This accident showed that the neighboring property, which had already developed slides during the dredging in the canal, would be endangered if a permanent lowering of the water level took place. The same property also suffered from the formation of crevasses, the displacement of the retaining wall along the line, and the presence in the canal slopes of unstable sands; considerable work was therefore necessary to prevent this partly saturated ground from slowly sliding toward the canal in the event of lowering the water level.

To carry out this purpose there have been driven in the bank of the canal and in the berm for the road, at a distance of 39.4 feet from each other, two rows of sheet piles, averaging about 39.4 feet in length and .49 foot in thickness. These are joined to each other by iron bolts and are intended to form tight partitions preventing the entrance of the unstable sands into the canal. These works, which were built in four and one-half months, cost $46,513.00 and have given excellent results. At the time when the water level was lowered 6.56 feet continuously from the 1st to the 14th of May, 1909 (1910?), no movement was produced in the nearby mass which overtopped the canal by a height of 213.3 feet (21.33 feet?).

Fig. 6. Elevation of lower end of Lock.



A special type of revetment for the protection of the banks has been found necessary on account of the unstable nature of the ground, and it has been applied to a considerable portion of the banks. It consists (Fig. E) of a protection of reinforced concrete placed upon piles and sheet piling. The revetment rests on a row of ordinary piles 22.9 feet in length and .59 foot to .72 foot in

diameter spaced at intervals of 8.2 feet, and on a line of sheet piles 16.4 feet by .26 foot with a slope of 1 on 2. The sheet piles are not placed in contact with the ordinary piling, but are held in place by two waling strips, 5 by 10 inches, the whole being firmly fastened to the piling by bolts 1 inch in diameter.

On this wooden structure is placed (with a slope of 3 on 4) a slab of reinforced concrete revetment which is 5.41 feet in height and has a concave surface with a minimum thickness of 5 inches at the center. This slab is formed of a concrete composed of 661.4 pounds of Portland cement and 8.5 bushels of sand to 3.28 cubic feet of gravel; it is reinforced throughout its height by a metal network having meshes 7.87 by 2.95 inches. This network is itself joined by metal strips .787 by .039 inch to a crossbar .31 inch in diameter passing along the upper portion in a concrete beading.

Fig. 7. Section A B C D

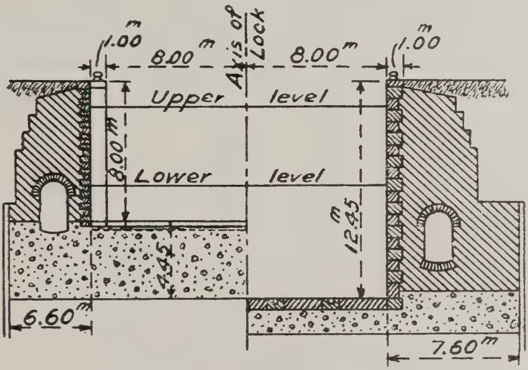
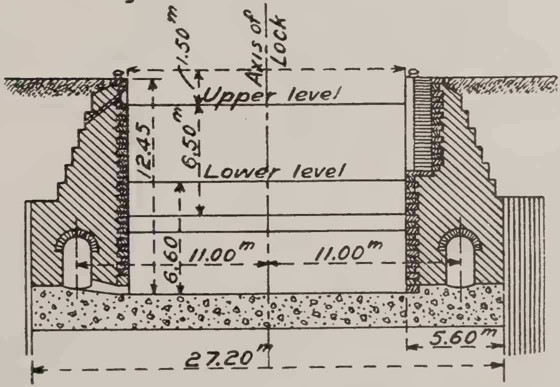


Fig. 8. Section E F G H



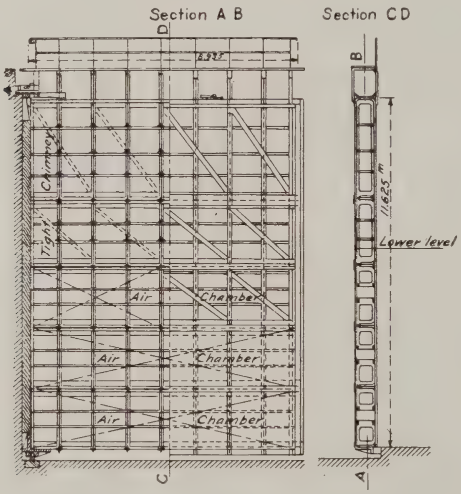
An expansion joint 0.8 by 0.8 inch is formed at intervals of 39.3 feet, continuity at the joint being obtained by the use of a covering slab of reinforced concrete 2.0 feet wide and 4 inches thick. The joint between the two slabs is formed by a film of asphaltic packing.

LOCKS

As a result of the rebuilding and the decrease in the number of pools, the four locks of the old canal which are included in the course of the new ship canal have been done away with, and the three new ones are situated at entirely different locations.

The first, called the Capelle-au-Bois lock, marks the end of the Brussels pool, which is 57,843.7 feet in length; its lift is 14.6 feet. The second pool is only 17,001.3 feet in length and its lock, that at Grand-Willebroeck, also has a lift of 14.6 feet. The third pool, 23.161 feet in length, consists for the most part of the new diversion of the ship canal, which is dug parallel to the Rupel. The depth of the channel up to the old mouth of the canal was not sufficient to insure easy access to ships drawing 21.3 feet of water. The lift of the guard lock at the junction with the Rupel, which is situated at Wintham, is 12.8 feet. As the level of the lower sill is fixed at —19.7 feet, there is obtained a depth of water of 34 feet at high tide, and this does not fall below a minimum of 21.3 feet even at low tide. In spite of the tidal effect in the Rupel, the canal is therefore accessible at all times to vessels drawing 19.7 feet, and

Details of Lock Gate.

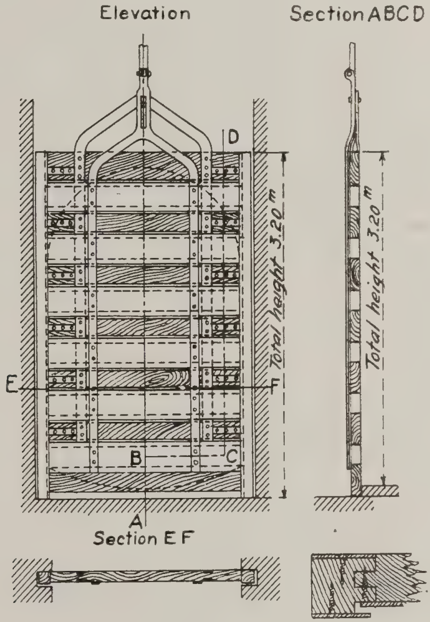


high tide may even make a lockage unnecessary by permitting entrance directly into the pool, the surface elevation of which is the same (+14.4 feet) as that of mean tide.

The plans adopted for the remaining locks call for a length over all of 485.5 feet, a useful length of 374 feet, and a width at the water surface of 52.5 feet, the total width of the structure at the base being 91.2 feet. (Figs. 4 to 8, inclusive.)

For a distance of 82 feet above and below the locks the canal bank is protected by a revetment of stones averaging 10 inches in height placed on a bed of concrete from 3.28 feet to 4.92 feet in thickness. The outer edge of the revetment is finished off by a line of sheet piling 3 inches in thickness fastened to a row of piles 10 inches in diameter and 18.04 feet long. The heads of the locks are protected by dams of sheet piles 3 inches thick, and either 18.0 feet or 14.8 feet high, driven in rows. These are held in place by piling 1 foot in diameter and from 18.0 feet to 21.0 feet in height.

Fig. 10. Details of Valve


Elevation

Section ABCD

Section E F

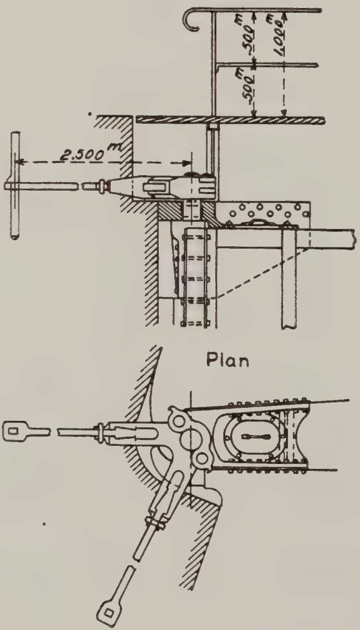
At a distance of 9.8 feet from the breast walls is placed a line of piles 10 by 10 feet and 39.4 feet long set side by side and this is carried entirely across the lock. Between these piles and the

bottoms of the breast walls the concrete reaches a thickness of 14.8 feet, but it is gradually decreased to a uniform thickness of 6.56 feet throughout the length of the lock proper.

The side walls have a maximum height of 40.8 feet and vary in thickness from 6.56 feet at the top to 18.4 feet at the bottom. This variation is obtained by successive offsets of 1.31 feet, which occur at intervals of 3.28 feet and begin at a height of 16.7 feet. In the lower portion of each wall is placed a culvert 5.57 feet wide and 9.84 feet high. About every 820 feet the thickness of these walls is increased by 6.56 feet to form counterforts (13.1 feet) in breadth. The wing walls at the heads are 14.4 feet thick at the bottom and 7.22 feet at the top with a coping 3.28 feet broad.

Fig. 11. Quoin Post.

Collar and Anchor bolts.



The filling and emptying of the lock chamber is effected through the two culverts, 5.58 by 9.84 feet, which have been mentioned as extending throughout the length of the side walls. They communicate with the lower part of the chamber by nine openings placed at 39.37-foot intervals. Each opening, which is 6.56 feet in length, has the mouth contracted to an oval 4.59 by 1.64 feet in order to lessen the violence of the currents. The gates at the

heads of the culverts (called also "larrons") are protected by strong gratings of iron rods .24 inch in diameter and spaced at 3.15-inch intervals, the frame and cross bars being formed of U-bars 2.36 by 1.42 inches by .28 inch.

A gate valve maneuvered by a hand-operated crank and pinion and a rack regulates the admission of water to each of the intakes. These valves, which are 10.8 feet high and 6.36 feet wide, are made up of plates .39 inch thick spaced at intervals of 59 feet. In the closed position of the valve these openings are covered by planks 1 foot wide and 4 inches thick. (Fig. 10.) (The planks thus overlap the edges of the plates.)

Fig. 12 Hollow Groin.

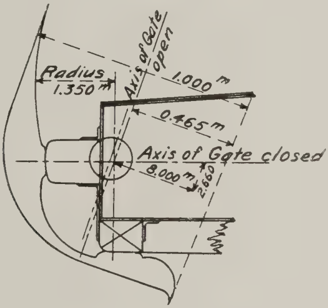
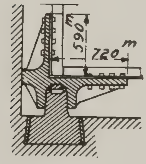
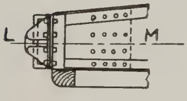


Fig. 13. Pivot.



Plan



These planks are fastened to channels 2.68 by 3.54 inches by .393 inch, and are reinforced at their ends by iron plates. The valve is framed by an iron plate 4.33 inches by .3 inch. Two strong iron braces 4.72 by 1.18 inches and 3.93 inches by .984 inch maintain the stiffness of the valve, the method of joining these braces permitting relative travel between plates and planks of .10 inch. The guides of the valve have grooves .36 foot wide and permit a

lateral play of about 1 inch. They are protected by iron plates 1.57 inches by .314 inch.

LOCK GATES

The lock gates are of the arched type with a radius of 118.1 feet. The length of the leaf is 30.3 feet, the height of the gates being 22 feet for the upper and 37.4 feet for the lower pair. They are arched, double skin gates built of plates whose thickness varies from 0.5 inch near the bottom to .31 inch at the top. Fig. 9 clearly shows the arrangement of the partitions which reinforce the leaf, especially toward its base, as well as the air chamber which is provided. The gate panels average 3.69 by 2.46 feet, the space between the skins or the thickness of the gate being uniformly 2.46 feet. A chimney-like opening 1.47 by 1.05 feet, formed by water-tight partitions, is carried throughout the height of the gate at the groin end. At the lower part a piece of oak .78 by .66 foot forms a bearing against the arc of the sill.

The pin at the top of the heel post, 7.87 inches in diameter, is held by a collar 7.87 inches broad to two anchor rods 8.20 feet long and 2.76 inches thick fastened in the masonry of the hollow quoin and held in place by vertical bars 3.28 feet high. (Fig. 11.) The lower pivot is formed of a steel trunnion 7.08 inches in diameter supporting the leaf whose socket fits over it; the bearing surfaces are two 4.72-inch plates. (Figs. 12 and 13.)

A foot bridge 2.55 feet wide, formed of three planks 2.5 inches thick and finished with a guard rail 3.28 feet high, provides a passage over the gates when closed. The gate when opened fits into a recess in the side wall 3.28 feet deep.

Two large diagonal foot bridges, 7.55 feet wide, are placed at each end of the lock and are intended for convenience in maneuvering the gates. The latter are operated by means of geared windlasses turned by hand.

For lockages of lighters and small boats, there have been constructed small locks joined to the main locks; these are 28.2 feet wide and 213.3 feet long, and are divided by an intermediate gate into two compartments of 147.6 and 54.5 feet useful length, respectively. These two smaller locks have a lift of 14.6 feet.

The work already done looking to the transformation of Brussels into a seaport has cost in all about $7,720,000, including $1,061,500 for the warehouses, etc.; $2,412,500 for the port of Brussels and $4,246,000 for the canal itself. All that now remains is the work

of dredging and deepening (which does not present especial difficulty) and the operations on the section parallel to the Rupel. In a short time (toward the end of 1912) the Belgian capital will see at its gates the large coasters which up to the present time have been stopping at Antwerp; moreover, the great prosperity of the latter city will in no way be affected by the development of Brussels as a seaport, for the insufficiency of the present facilities for trade by water is notorious.

To meet the demand for rapid freight handling, the port of Brussels has been equipped with the most modern appliances; of these nineteen cranes, either electric or steam, are in operation. A 10-ton engine has been obtained especially for the unloading of large stone; each 4-ton grappling crane will unload daily a boat load of 400 tons of coal. A storehouse and a sorting arrangement for coal, which can care for about 200,000 tons per year, has been installed near the wharves. An electric lighting system has been put into service on the wharves of the various harbors.

A single river steamboat company, ''L'Union,'' now handles an annual traffic of 100,000 tons; with a view of using the ship canal they have already made plans to build 6,561 linear feet of wharves in the outer harbor. This extension of the harbor also includes railroads, streets and approaches, sheds, cranes, and various buildings to be erected on the ground acquired by the state between the ship canal and the depot at Schaerbeek.

It should be noted that it has been necessary to prosecute the work on the harbor and the canal under exceptional difficulties, since it has been carried on so as not to interrupt the navigation of the old canal. Instead of being hindered, the trade has developed wonderfully, the tonnage having risen from 1,700,000 tons in 1898 to 2,600,000 tons in 1909. Such a rapid increase can only be a good omen for the success of the seaport of Brussels.

TIMBER FOR PONTON MATERIAL

BY

Lieut. JOSEPH H. EARLE

Corps of Engineers

It appears that the supply of white pine suitable for ponton material is rapidly becoming exhausted; and the Engineer Department has, through various district offices, attempted during the past two years to find a satisfactory substitute. These attempts have not been entirely successful; another species of timber having the necessary qualifications of strength, lightness, and durability being very hard to find.

In July, 1909, authority to purchase and test specimens of certain western woods to determine their suitability for the purpose in question was received by the District Engineer Officer, Seattle. It was desired that white pine, sugar pine, Port Orford cedar, western yellow pine and upland spruce be tested; but white pine, sugar pine, and western yellow pine were found to be unobtainable in the sizes, quality, and quantities necessary, and tests of these species were dispensed with.

Specimens of Port Orford cedar and of upland spruce were obtained and were tested by Mr. O. P. M. Goss, Engineer in Timber Tests at the University of Washington. Extracts from the report of Mr. Goss follow:

MATERIAL

The material furnished, upon which tests were made, consisted of 6 pieces each of cedar and spruce. All of these pieces were approximately 32 feet long when received at the laboratory and were all cut to a length of 27 feet before being tested. The spruce and cedar pieces were nominally 4¾ by 4¾ inches and 5 by 5 inches in cross section, respectively. All material was green when tested.

SPECIMENS

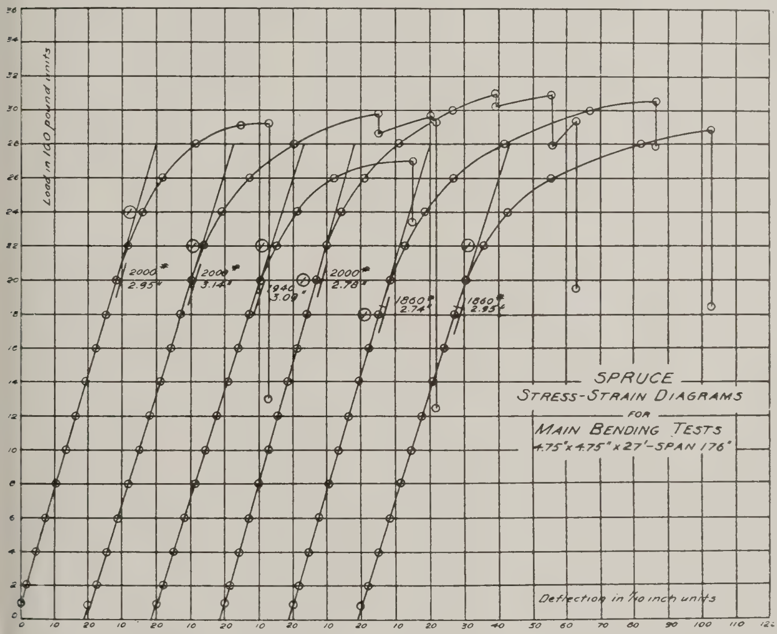
Each main piece was tested as a beam and after test two 2 by 2 by 48 inch specimens were cut, one from the uninjured portion of each end of the main piece. These 2 by 2 inch strips furnished two

specimens each, a 2 by 2 by 30 inch stick for a small bending test, and 2 by 2 by 8 inch stick for test in compression parallel to grain. There were in all six main bending, twelve minor bending, and twelve end compression tests made on each species, or a total of sixty tests.

TESTING

1. *Main Beams.* Each main beam was supported on a span of 14 feet 8 inches and was placed so that the center came directly under the center of the moving head of the testing machine.

Rocking supports were placed on each arm of the testing machine at a distance of one-half the span from the center. Cast-iron plates 4 inches wide were centered over these rocking supports, and served as bearings for the specimen. The load was applied at the center of the span and was transmitted into the beam through a rounded bearing block. This block was made of oak and had a radius of curvature of about 16 inches.



A fine wire was stretched along the neutral axis of the beam and supported by nails driven directly over the center of each support. Behind this wire, at the center of the span, a steel scale was fastened firmly to the beam. When the load was applied, the scale descended with the beam and the wire remained stationary. The deflection due to the load applied was read to one one-hundredth of an inch by means of a transit.

The load was applied uniformly and the corresponding deflections

for even increments of load were read "on the run." The maximum load sustained was recorded.

2. *Small Bending Test.* The small bending test was made in a very similar manner to the large test, except that the deflections were measured by means of a special deflectometer. The principle, however, is just the same as described for the main test and the same general operations were performed in both tests.

3. *Compression Parallel to Grain.* This test was a direct end-crushing test and maximum load readings were recorded. The specimen was placed on a plate resting on a spherical bearing to give proper adjustment.

The cedar and spruce tests were conducted in identically the same manner and on the same machines, so that the results are entirely comparable.

All specimens were weighed immediately after being tested, the failure sketched, and a moisture section cut. This moisture disc was weighed on a chemical balance, dried in the drying oven at 100° C. to a constant weight and reweighed. The moisture percentage was calculated, based on the absolute dry weight.

RESULTS

The results obtained are set forth in Tables 1 to 4. Table 1 shows a summary of all main bending tests. From this table it will be seen that the average oven dry weight per cubic foot for spruce is 23.2 pounds, while that for cedar is 28.4 pounds, or spruce is only 81.7 per cent as heavy as cedar. Column 9, Table 1, shows spruce to be only 82.8 per cent as strong as cedar when weight is neglected, basing the comparison on the modulus of rupture. Column 11 shows that spruce is 91.8 per cent as stiff as cedar, neglecting the difference in weight of the two woods.

Table 2 shows the results of the small bending tests compared in the same manner as those for the main tests. In this table spruce in the oven dry condition is 81.4 per cent as heavy as cedar, which checks very closely with the figures obtained in Table 1. In this table column 9 shows that spruce is 77.3 per cent as strong as cedar, based on the modulus of rupture, and column 11 shows that it is 92.5 per cent as stiff as cedar. These are the same general results as shown in Table 1.

Table 3 shows results of end compression tests. From this table, column 8, spruce is 81.7 per cent as heavy as cedar, which again checks similar figures in Table 1. Column 9, Table 3, shows the crushing strength of spruce to be 78.1 per cent as great as that of cedar.

In order to compensate for weight of the two species, Table 4 was prepared. This table simply gives ratios of the various factors indicated to the dry weight per cubic foot. Columns 1 to 4, inclusive, show very favorable for spruce. Columns 5 to 8, inclusive, show a little less favorably, while column 9 shows still less in favor of spruce. Adding the various factors shown in Table 4 and di-

TABLE NO. 1. MAIN BENDING TESTS.

	1	2	3	4	5	6	7	8	9	10	11★	12	13
Species	Number sticks tested	Grade	Normal Cross Section	Span	Rings per inch	Moisture percent	Wt. per cu. ft.		Mod. of Rupture / sq. in.	Fibre stress at elastic limit / sq. in.	Mod. of Elasticity / sq. in.	Hor. shear developed / sq. in.	Elas. res. in. lb. cu. in.
							as tested	oven dry					
SPRUCE Average Maximum Minimum	6	Clear " "	4.75" X 4.75" " " " "	176" " "	23.7 28.0 21.0	25.5 26.1 24.6	29.1 30.0 28.3	23.2 24.1 22.5	7272 7720 6620	4793 4970 4570	1774 1943 1671	98 104 90	0.720 0.793 0.639
CEDAR Average Maximum Minimum	6	Clear " "	5.00" X 5.00" " " " "	176" " "	9.9 14.6 7.6	26.8 28.3 25.3	36.0 37.5 34.2	28.4 30.0 26.7	8775 10310 7430	5540 6010 4960	1934 2240 1776	124 146 104	0.885 1.000 0.769
SPRUCE In per cent of cedar							80.9	81.7	82.8	86.4	91.8	79.0	81.3

TABLE NO. 2. SMALL BENDING TESTS.

SPRUCE Average Maximum Minimum	12	Clear " "	2.00" X 2.00" " " " "	28" " "	23.5 33.5 15.5	27.5 28.8 26.4	30.1 31.9 28.9	23.6 24.9 22.7	6712 7150 6150	3808 4310 3020	1407 1607 1253	242 258 223	0.580 0.729 0.334
CEDAR Average Maximum Minimum	12	Clear " "	2.00" X 2.00" " " " "	28" " "	10.0 17.5 7.0	29.1 30.2 27.5	37.4 40.6 35.3	29.0 31.4 27.1	8682 10360 7050	4596 5520 3860	1522 1830 1130	311 372 253	0.782 1.038 0.587
SPRUCE In per cent of cedar							80.5	81.4	77.3	82.8	92.5	77.8	74.2

★Modulus of elasticity given in 1000 pound units

TABLE NO. 3. END COMPRESSION TESTS.

	1	2	3	4	5	6	7	8	9	10
Species	Number of Pieces	Grade	Normal Dimensions		Rings per inch.	Moisture percent	Wt. per cu. ft.		Maximum crushing strength	
			Cross section	Length			As tested	Oven dry		
SPRUCE Average Maximum Minimum	12	Clear " "	2" X 2" " "	8' " "	23.0 35.0 12.0	30.9 33.7 28.5	30.9 32.5 29.5	23.6 24.8 22.6	2903 3150 2630	
CEDAR Average Maximum Minimum	12	Clear " "	2" X 2" " "	8' " "	10.3 15.5 6.0	30.1 30.8 29.0	37.6 42.3 34.3	28.9 32.5 26.3	3723 4480 3150	
SPRUCE In per cent of cedar							82.2	81.7	78.1	

TABLE NO. 4. SUMMARY OF ALL TESTS.

	MAIN BENDING TESTS.				SMALL BENDING TESTS.				Comp parallel to grain	
Species	Modul. of rupture Dry wt.	Fibre stress at elasticity limit. Dry wt.	Modul. of elasticity Dry wt.	Elastic resistance Dry wt.	Modul. of rupture Dry wt.	Fibre stress at elastic limit. Dry wt.	Modul. of elasticity Dry wt.	Elastic resistance Dry wt.	Maximum crushing strength Dry wt.	Factors for all tests Dry
SPRUCE CEDAR	313 309	206 195	76.4 68.0	0.310 0.312	28.4 29.9	161 158	59.6 52.4	0.246 0.269	123 129	407 403
SPRUCE In per cent of cedar	101.4	105.6	112.4	99.3	95.0	101.8	113.8	91.5	95.3	101.0

viding this sum by the average weight per cubic foot, spruce has the advantage by just 1 per cent. Spruce shows quite a gain over cedar in stiffness, however (see columns 3 and 7, Table 4). This advantage is 12.4 per cent for the main bending tests and 13.8 per cent for small bending tests.

CONCLUSIONS

1. For equal volumes greater strength was developed in cedar.
2. For equal weights slightly greater strength was developed in spruce.
3. Cedar exhibited a greater brashness than spruce.

It is unfortunate that specimens of white pine were not obtainable for test, as a direct comparison between that species and those tested would have been valuable. "Principal Species of Wood—Their Characteristic Properties," by C. H. Snow, C. E., Sc. D., Dean of Applied Science at New York University, gives the following data:

	Weight per cubic foot	Modulus Elasticity	Modulus Rupture
White pine	24	1,390,000	7.900
Sugar pine	22	1,120,000	8.400
Port Orford cedar	28	1,730,000	12.600
Western yellow pine	29	1,260,000	10.200
From the tests made by Mr. Goss:			
Port Orford cedar	28.8	1,659,000	8.700
Upland spruce	23.5	1,529,000	6.900

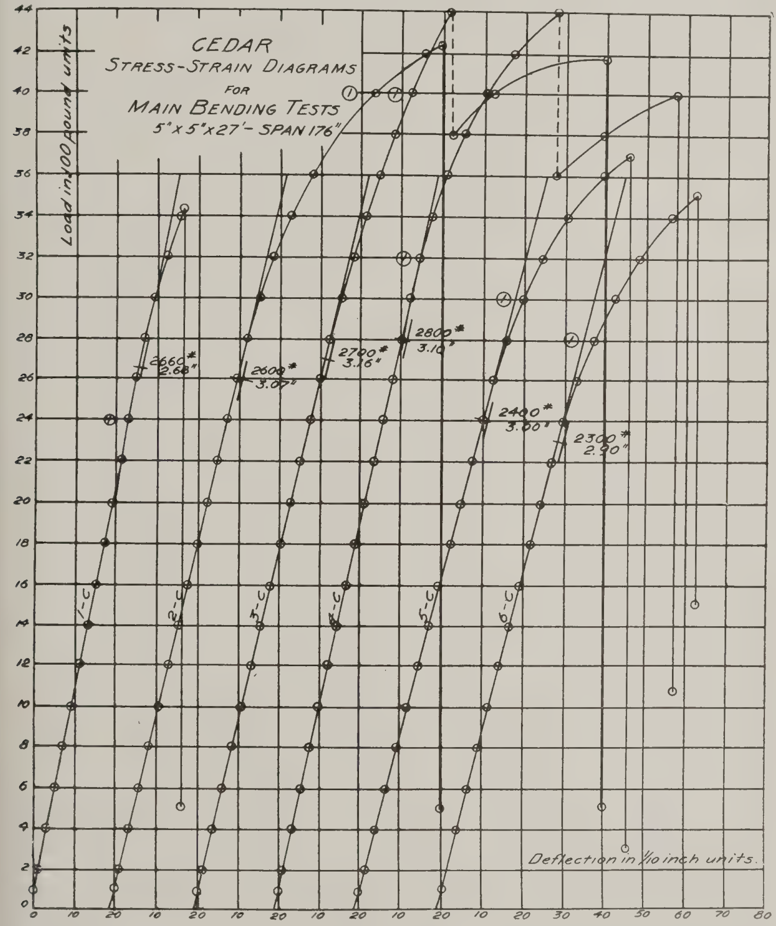
The specimens tested at the University of Washington were unseasoned.

The Engineer Field Manual, Part 2, page 201, gives the safe concentrated center load on a bay of the reserve bridge as 4,750 pounds, with a factor of safety of 4. It is thought that the main beam tests were made by Mr. Goss in such manner as to correspond very nearly with actual conditions in ponton service. The pieces of upland spruce were dressed to 4¾ by 4¾ inches. The average breaking load was 2,920 pounds. By computation, five spruce balk of 5 by 5 inches cross section will have a safe load, factor of safety equal to 4, of 4,230 pounds. It is probable that seasoning will increase the strength of spruce.

Two other species are now being tested for comparison with the above, under the supervision of the District Engineer Officer, Seattle; but results of such tests will not be available for use in this article. These species are Alaska yellow cedar and Washington red cedar.

Chess made of Washington red cedar have been used by the En-

gineer Detachment at West Point, N. Y., and in August, 1910, Capt. W. P. Wooten, Corps of Engineers, Instructor of Practical Military Engineering, U. S. M. A., compared the strengths of white pine and Washington red cedar chess in use by breaking two of each species with concentrated loads.



Following data is from Captain Wooten's tests:

Specimen	Material	Size	Weight	Span	Maximum deflection	Breaking load
No. 1	White pine	13′×12″×1½″	53½ lbs	11′	15¼″	955.5 lbs
No. 2	Red cedar	13′×11¾″×1⅜″	26 lbs	11′	13¼″	457 lbs
No. 3	White pine	13′×12″×1½″	44 lbs	11′	13¼″	783 lbs
No. 4	Red cedar	13′×11¾″×1⅜″	24 lbs	11′	17″	396.5 lbs

From this it appears that Washington red cedar is only 57 per cent as heavy as white pine and is 60 per cent as strong; so that it would be possible to increase the dimensions of pieces of Washington red cedar used in the construction of ponton material in such manner as to obtain equal strength to that of white pine material without increasing the weight.

The increase in size, however, is objectionable, as a change in dimensions of one portion of the ponton material would necessitate changing the other portions, in design of wagons, etc.

It is therefore desirable to find a species that has practically the same strength, weight, etc., as white pine. Of the species investigated the only one that seems to fill this requirement is upland spruce. This wood from the tests described above, appears to have about the same strength and weight as white pine. It grows in abundance in the Northwest and to such sizes as to make any of the unusual dimensions called for in construction of ponton material easily available at prices between $20.00 and $35.00 per thousand feet board measure. Spruce will probably not last so well as white pine under varying conditions of weather; it has not the resinous quality of the latter wood and absorbs moisture more rapidly. Treatment by brush preservative which will not greatly increase weight or cost, may overcome this disadvantage.

Canvas ponton frames and trestles for a division of an advance guard train have recently been made of upland spruce in Seattle and shipped to the Philippine Islands. This material was thoroughly coated with red lead and painted with two coats of copper paint. Balk and chess for two bays of a reserve train brushed over with two coats of avenarius carbolineum have also been made of this material, in Seattle, and sent to Vancouver Barracks, Wash., for use by the engineer company at that place.

From standpoints of strength, weight, and abundance of supply upland spruce is a first-class substitute for white pine; experience with the material made of this wood now in use will in the not far distant future furnish better information than is now obtainable concerning the suitability of spruce for the purpose of ponton construction from a standpoint of durability.

A FIELD PILE DRIVER

BY

Lieut. RICHARD PARK
Corps of Engineers

In October, 1909, the Engineer Equipment Board, meeting at Washington Barracks, directed Lieut. W. H. Rose, Corps of Engineers, to investigate the subject of portable pile drivers with electrical hoists and submit to the Board recommendations as to what design would be most suitable for use by an army in the field. It was stated by the Board that the portable searchlight outfit already purchased was the contemplated source of power, and it was further stated that the equipment should be capable of being carried on two ponton wagons of the bridge train, the maximum load for a single wagon to be taken at 3,000 pounds.

The pile driver described in this article was designed to comply with these instructions. The general features of the design were worked out by Lieutenant Rose, and general specifications furnished the Lidgerwood Manufacturing Company, who worked out the details, and, after approval, manufactured the outfit as herein described.

A general idea of the construction of the hoist and driver can be had from the figures accompanying this article. Spruce was used for the framework in order to combine lightness with strength. The leads, which are spaced by three wrought-iron yokes, are arranged to swing about a steel pin which passes through the upper yoke and the head of the A-frame support. A projecting flange of the lower yoke travels along the curved upper surface of the lower guide beam, which surface is protected by a wrought-iron plate. Holes are bored through the plate and into the guide beam and, also, through the flange, and steel pins provided which fit these holes and so enable the swinging leads to be held at the desired angle. This arrangement was adopted so that, by driving the piles on a batter, an entire bent could be driven without shifting or swinging laterally the whole driver.

Near the top of the A-frame two inclined braces are attached, the lower end of which are fastened to the side timbers of the bed frame. These side timbers are trussed with turn-buckled wrought-iron rods, so that the driver can overhang at least as far as the king-post, which gives it an effective overhang of 13 feet 6 inches.

A platform with holding-down ringbolts for the hoist is constructed on the rear end of the bed frame.

For facility of transportation the knockdown principle is employed, all joints being made by bolts and fish plates or specially shaped wrought-iron fittings. For ease and rapidity of assembling, an assembly diagram has been prepared in which every joint is given a designated number. These numbers are branded on all the wooden members at each joint and stamped in all iron fittings, so that the driver can be assembled in a very short time, even by inexperienced men.

The hoist is a special single drum, reversible type, with a drum 10 inches in diameter, rated to raise 1,000 pounds at a speed of 180 feet per minute. It is fitted with Spencer Miller patent air-cooled metallic slip friction device, and provided with a ratchet and pawl for holding the hammer suspended. It is compound geared to the electric motor, the motor gears having eighteen and fifty-five teeth and the drum gears fourteen and fifty-two teeth, respectively, so that the speed reduction is 1 to 11.3. The motor is a General Electric, compound (cumulative), enclosed type, 90 volts, 7 horsepower, 800 revolutions per minute with reversing controller.

The hoist, complete, weighs approximately 2,200 pounds; the framework, complete, 3,000 pounds, and the hammer, 800 pounds. In order that the framework could be carried on the standard ponton wagon, the maximum length of the timbers was fixed at 27 feet.

The electric hoist, while it is light, compact, and reliable, has the important disadvantage of making the pile driver dependent in the field on a portable source of electric power. While portable electric generating sets are necessary for field searchlight operation, and while in many cases they might be available for use with the pile driver, especially those forming a part of the Engineer searchlight equipment, yet in other cases it might be extremely inconvenient, if not actually impossible, to detach a generating set for use with the pile driver.

A gasoline engine hoist would make this outfit independent of the field searchlights and so obviate the most important objection to

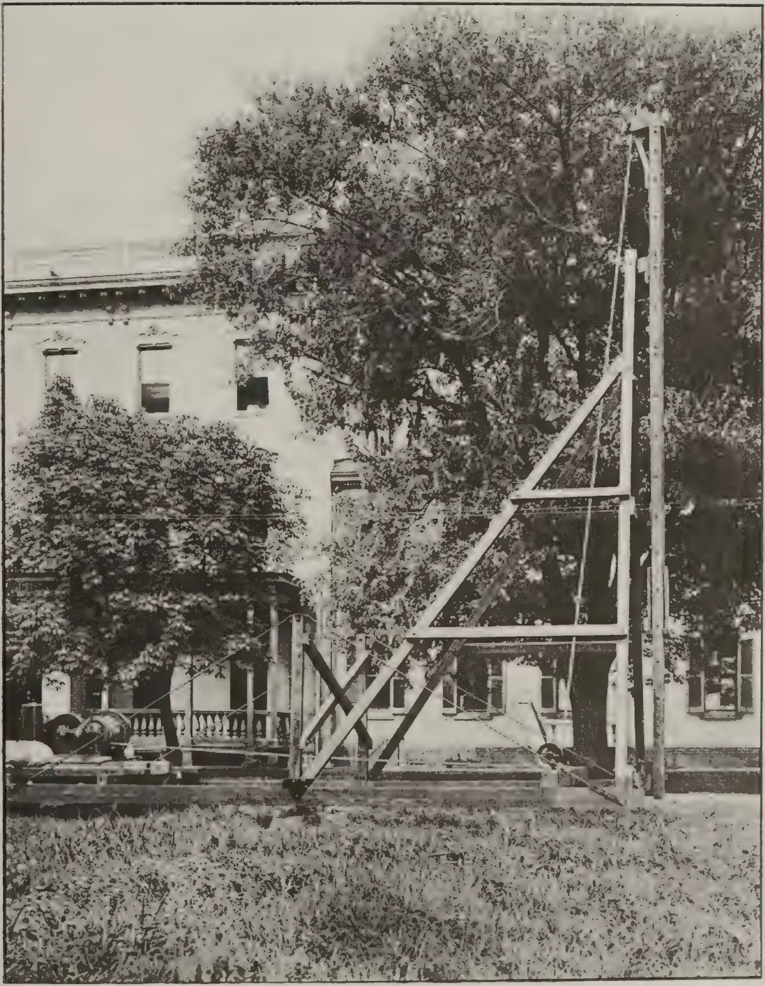


Fig. 1. Side View of Pile Driver, Showing Position of Motor and Lines

the electric motor drive, and it is understood that endeavors are being made to purchase a suitable gasoline engine hoist.

The pile driver with the electric hoist was turned over to the writer for experiment at the Pine Camp Maneuvers during August, 1910, and, in general, gave good results. The report which follows was submitted as a result of the experiments at Pine Camp and it is thought may be of interest as showing the fitness of the outfit for practical use with a field army.

* * * * * * *

The framework is so designed that it can be completely dismantled, excepting the hammer ways which remain as a unit. The result is that all the parts lay nicely on a single ponton wagon. The rods and bolts are packed in a suitable chest along with the rope, blocks and tackle, and necessary tools. The Lidgerwood drum hoist and hammer can be easily loaded on another wagon, along with the rope and bolt chest. Four mules are required to haul each wagon, and six should be used on difficult roads.

Every timber, rod, bolt, nut, and brace pertaining to the pile driver is properly marked in such way that no mistake can be made in assembling the framework. In fact, without any drawings of the apparatus it was erected at Pine Camp in a little over three hours by a few inexperienced men. It can be assembled ready for work in an hour and a half by an experienced detail.

At Pine Camp the pile driver was operated on four days, two of these being half-day periods. The ravine over which a pile bridge was being built was distant over a mile from camp, and much time was lost by the details in going to and from camp. The work of driving the piles, sawing the tops, placing the cap sills, and moving the pile driver from the completed bents out for the next bent, occupied eighteen hours actual working time. The average time taken to saw the butts square and place a cap sill, drift-bolting it to the caps, was two hours. The pile driver was moved out over the shore bay to the position of the first bent on log rollers laid on the sand in the bottom of the deep approach cut. In moving out over the bridge the logs were replaced by balk, and 4-inch iron pipes were used as rollers. Considerable time was lost in getting the pile driver off the log ways on to the balk. This took two hours, and an hour was consumed during each of the other three advances, making a total of five hours lost in maneuvering the pile driver into position.

From the eighteen hours work with the pile driver then, the six

EXPERIMENTAL

PORTABLE FIELD PILE DRIVER

Designed By

1st Lt. W. H. ROSE, C.E.

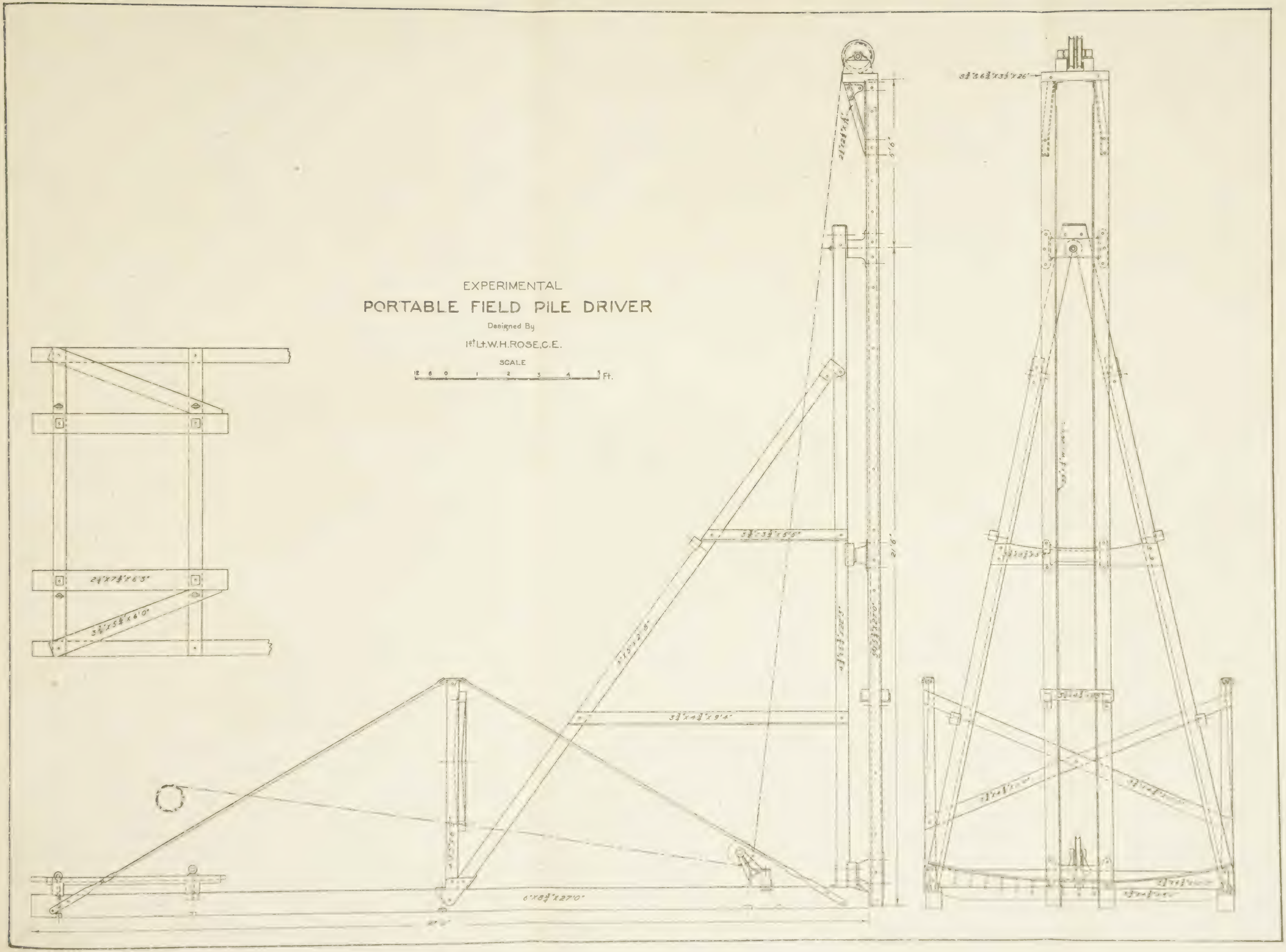


Fig. 2. Front View of Pile Driver, Showing Leads Placed for Driving Battered Piles

hours for placing the cap sills and the five hours for maneuvering the pile driver must be deducted to find the time that the hoist was in operation driving the hammer and lifting the piles from the bottom of ravine into position in the ways. Thus we get seven hours as the actual time the electric hoist was in operation on the piles.

During this time four 15 foot, four 20 foot, four 30 foot, and three 35-foot piles were driven on the average 10 feet into the ground. The first eight piles were driven through sand entirely, the next four through a slight depth of loam, the last three through 2 feet of wet mud and sand.

The average time taken to drive a pile was then twenty-eight minutes, and this includes hoisting the pile from the ravine bottom, adjusting its foot at the proper place on the ground and adjusting its cap in the ways.

The actual time taken to drive each pile in the shore bent was much less than twenty-eight minutes, and the actual time used in maneuvering the big 35-foot piles and driving was correspondingly more than twenty-eight minutes.

No record was kept of the number of blows it required to sink the piles the desired depth. It was attempted to drive all piles to a depth of about 10 feet, and the length of the piles in some cases determined this depth, rather than the failure of the hammer to drive farther. In other cases the driving was stopped short of the normal depth when the hammer with a full drop would not drive the pile an inch.

On the first day's work the Dock engine operated well and sufficient power was available. On the second day the magneto weakened and the hammer had to be nursed up to the top of the ways, and the engine rested after each drop in order to get it up to speed again. The rest of the time the engine was operated off the battery and sufficient power was available.

The average driving time per pile, twenty-eight minutes, may seem long, especially since the two shore bays were driven with small, easily driven piles, and then, too, it was noticed that with the first two or three drops from 3 to 4 feet were gained at the very start.

It may, however, be stated that the pile driver detail, from the officer in charge down, were all green hands at such work, and entirely unskilled in the handling of a hoist, which latter was found to require a surprising amount of care and skill in order to check

the hammer rope and electric drum at the right instant. Further, three different details of enlisted men, two from B Company and one from C Company, were used as crews, the first B Company detail erecting the pile driver, excavating the approaches, clearing the slopes, cutting, hauling, and carpentering the piles and sills, and driving the piles the first two days. The second B Company crew was taken out at 5.30 one evening and worked until 10.30 by the light of searchlights. The C Company crew put in a half day's work the last day the pile driver was operated.

In view of the inexperienced men handling the work, the troubles with the gas engine operating the generator, and the scattered opportunities for operating the pile driver, due to the absence of the officer in charge and the details at the maneuvers nearly every day, the results that were obtained proved that the pile driver, even under most adverse conditions, can handle heavy piles and drive them into sand with fair speed, and show that under favorable conditions in the field with a mobile army the pile driver will prove a vast improvement on the makeshift hand pile drivers, and average up well with the best portable steam plants of the same capacity.

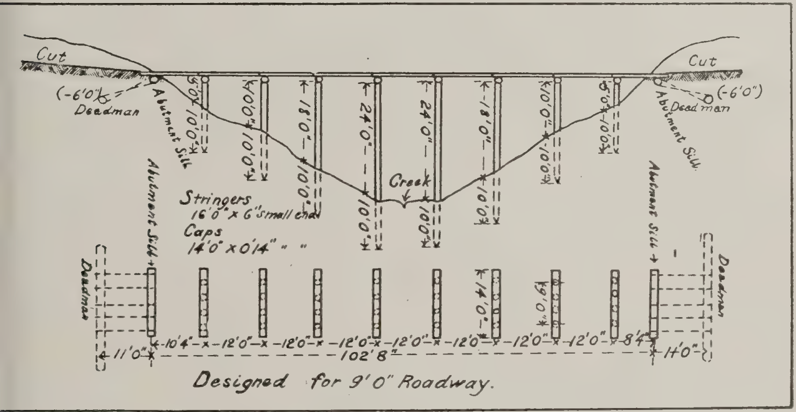


Fig. 3. Bridge, in Plan and Profile

A few minor defects will be taken up in detail. It was found difficult to keep the hoisting rope on the base pulley. This should be remedied by designing a suitable guard. The rope ring at the hammer twisted badly and tended to cut the rope. On the hammer ways are four strap iron hooks forming supports for the hammer guards. Unless the hammer is operated by an expert there is apt to be trouble keeping the slack out of the rope. There

were no experts at hand to operate the hoist, so the hammer many times was followed by some slack, which several times allowed the rope to get twisted around the guard supports with the result that before the hoist could be stopped the rope broke. The necessity for having the hammer guards placed where they are is apparent, but they should be so designed as not to have sharp angles or edges placed so that a rope might catch on them and be cut.

It is therefore recommended for the pile driver:

1. That the bottom pulley be fitted with a suitable guard.
2. That the hoisting rope be fitted with a circular rope guard.
3. That U-shaped supports or staples for the hammer guards replace the present sharp-angled L-shaped hooks.

A MILITARY SUSPENSION BRIDGE

BY

Lieut. C. L. STURDEVANT
Corps of Engineers

The accompanying photographs show a suspension bridge constructed during engineer drill periods by the mounted section of Company D, First Battalion of Engineers, assisted, during the latter part of the work, by the bridge section of the same company.

The bridge was built on level ground, with a span of 100 feet between towers and carried a 9-foot roadway. Fig. 1 shows the arrangement of the cables, the bridge loaded with 104 men, and the construction of the trusses.

The anchors consisted of an inclined spar bearing against two horizontal deadmen. The cable passed between the deadmen and around the spar.

The cables used were the $\frac{5}{8}$-inch wire rope issued to engineer companies. Two cables on each side carried wooden blocks to which were attached the suspenders. The blocks insure an equal division of the load between the two cables and are less injurious to the cable than metal clips. The three blocks nearest the towers were held to their proper places on the cables by auxiliary $\frac{3}{8}$-inch cables, wrapped in succession around the blocks, passed over the tower, and attached to independent holdfasts. The other blocks, having less tendency to slide, were held in place by a single No. 10 wire.

The slings consisted of four strands of No. 10 wire, wrapped entirely about the blocks and transoms to develop full strength.

The transoms, every 5 feet, were in general 8 by 8 inches. Five balk, lashed at each transom, were used to carry the 11-foot chess of the advance guard ponton train. Diagonal wires crossing between transoms, together with floor stringers, formed a horizontal truss. Side-rail balks and lashings and side trusses prevented vertical oscillations.

The trusses were of the Pratt tpye, wires being used for the tension members. Since, when one-half of the bridge is loaded, the cable brings an upward load on the other half of the truss, it

is possible to get a reversal of the stress in practically any member. Consequently, the truss should be counter-braced throughout. The lack of this arrangement was plainly shown when the men marched on the bridge.

The photograph shows 104 men on the bridge. It had previously been loaded with 26 horses and nearly as many men and, later, a load of stone weighing 5,550 pounds was drawn across by a team of mules weighing 1,960 pounds. The first load produced a deflection at middle of about 18 inches. With the load off, the cables returned to their original position, showing that the anchors were holding rigidly. The load of stone, although producing less deflection, broke three of the wire members of the trusses. The wires, however, had been severely strained by twisting with a rack stick—a bad construction.

It will be seen from the foregoing that the weight of the bridge is excessive and that the cables form the weakest element. This lack of proportion is due to the fact that the most readily available material was used. Nevertheless, the bridge could be used as follows with a factor of safety in the cables approximating 2 : 5.

By infantry in twos;

By cavalry in file;

By light artillery, one carriage at a time;

By siege artillery, teams to cross and guns to be pulled across with ropes.

It may occur, in the mountainous country, that a bridge is desired at a place reached by trail only—one, perhaps, to enable mountain artillery to reach a commanding position. Other similar conditions may arise where pack transportation must be relied upon.

Under such circumstances, the engineers could readily organize a pack bridge train from the pack train as now prescribed. The mounted section would usually furnish the personnel. The carpenter, pioneer, and demolition packs would not be changed. The supply packs would be altered to suit the particular conditions and would carry, among other things, lashings, nails, metal clips, thimbles, and staples. Two or more supply packs might be necessary, depending upon the size of the bridge contemplated.

To the above would, then, be added "cable mules" and "wire mules." A fair-sized mule will carry 300 feet of ⅝-inch cable. Fig. 2 shows a "cable mule." The ordinary diamond-hitch was used, and no difficulty was experienced in transporting the pack.

Fig. 1. View of Bridge Loaded With 104 Men

Fig. 2. Pack Mule Loaded With Suspension Bridge Material

A SIMPLE DERRICK WITH ADJUSTABLE BOOM

Maj. Charles Keller, Corps of Engineers, furnishes us from the United States Engineer Office at Rock Island, Ill., the accompanying drawings and information in regard to a cheap and simple derrick with an adjustable boom, which it is thought will find a place on the works of many readers of the PROFESSIONAL MEMOIRS. The derrick is a standard 4-ton derrick and was originally designed by a firm of contractors in Chicago, Ill. Details of the same were furnished to Major Keller by Mr. E. E. Barrett, a member of the firm, who was for a number of years employed on the engineering work in the Rock Island District.

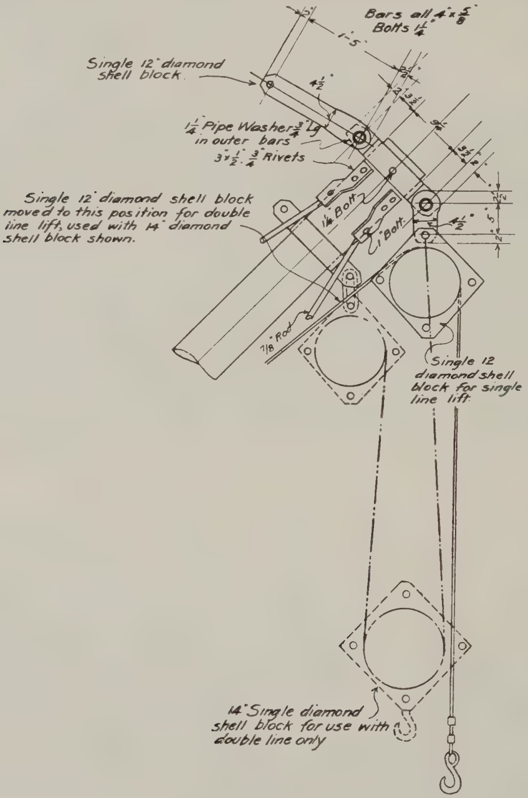
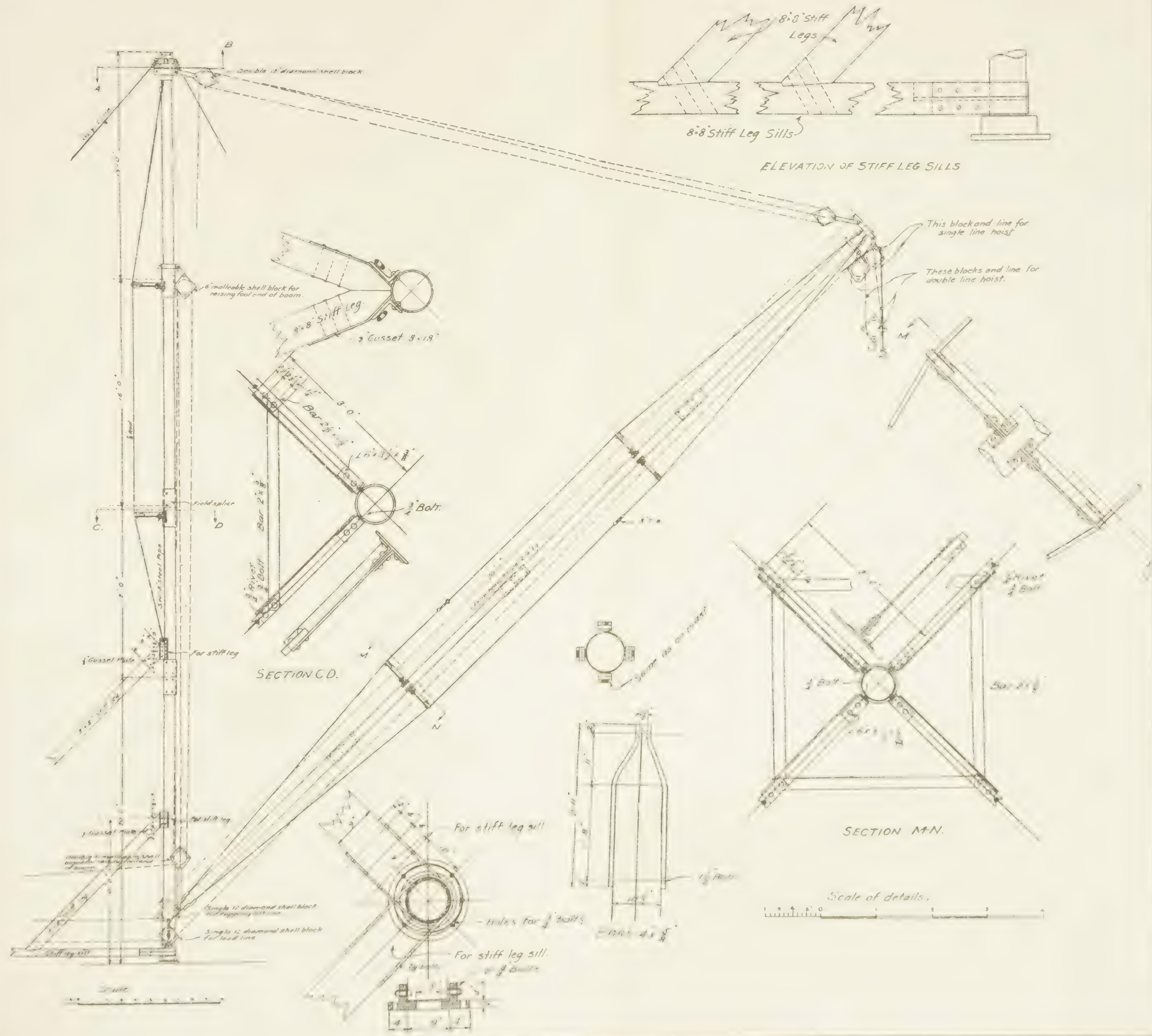
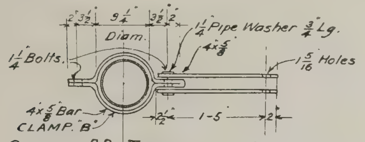
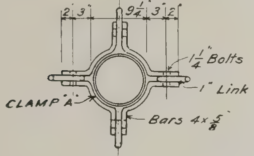


Fig. 1


8"×8" Stiff Legs
8"×8" Stiff Leg Sills
ELEVATION OF STIFF LEG SILLS
B
A
Double 12" diamond shell block
6" malleable shell block for raising foot end of boom.
8"×8" Stiff Leg
Gusset 8×18"
Bar 2½×⅜
L 6×3½×⅜
3'-0"
¾" Bolt.
Bar 2×⅜
¾" Rivet
¾" Bolt
SECTION C.D.
16'-0"
Field splice
C.
D
8" Steel Pipe
For stiff leg
Gusset Plate
8×8 Stiff Leg
This block and line for single line hoist
These blocks and line for double line hoist.
M
N
¾" Bolt
Bar 2×⅜
SECTION M-N.
For stiff leg sill
Holes for ¾" bolts
For stiff leg sill.
¾" Bolts
Single 12" diamond shell block for topping lift line
Single 12" diamond shell block for load line
Stiff leg sill
1½" Bolt
10½"
Bar 4×⅝
Scale of details.
Scale



SECTION AB TOPPING LIFT ATTACHMENT.



TOP VIEW, GUY ATTACHMENT.

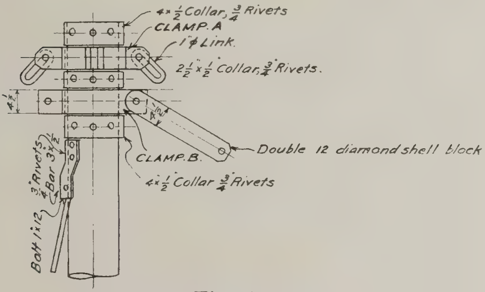
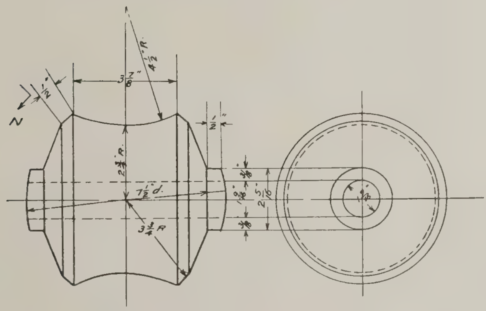
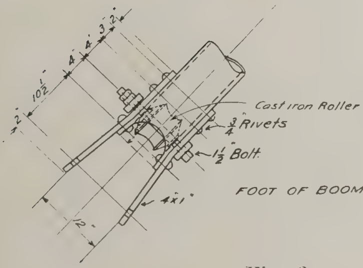


Fig. 2



DETAIL OF CAST IRON BOOM ROLLER
Scale 3/8" = 1'-0"



FOOT OF BOOM

Fig. 3

The derrick is in general terms made up of steel piping. Its adjustable boom, ease of erection and durability of its material, make it a very useful appliance. The design of the derrick has not been patented.

On the erection of a 1200-ton coal pocket at Baltimore, Md., the cost of lumber erection was only $9 per thousand feet board measure, whereas the usual erection cost was about $12 per thousand. The cost of the derrick, without blocks and tackle, is about $315. For operating the derrick, a 6¼ by 8-inch double cylinder, double drum hoisting engine with boiler attached was used. Any standard hoisting engine will answer the purpose. One of the drums is used for operating the boom and the other for the hoisting line, a winch head being used for raising and lowering the end of the boom. Stiff legs do not interfere with this raising or lowering of the boom, which can be operated with safety for about 20 feet above the base. If it is desired to raise the boom a greater height than this above the base, an extra pair of braces should be attached on the back of the mast at the point of greatest thrust.

A CIVILIAN'S SUGGESTIONS FOR A TECHNICAL RESERVE FOR THE ARMY*

BY

MR. CARYL D. HASKINS

To no other people in the world is the national military establishment so completely an unknown activity as to the people of the United States of America.

The ties which bind our Army to even the best educated classes of the nation are thin and weak, and rest almost wholly on romance and other thoroughly impractical influences.

The ties of familiarity and sympathy which are inherent in the great conscription nations of Europe, and for other reasons equally inherent in that one other great nation where volunteer service alone fills the ranks, is lacking with us.

Certain old doctrines, unmodified by the progress of the last century, still serve to lull even the most intelligent. The fact that hours, not miles, are the true measure of remoteness from other lands is utterly neglected, and the miles of safety maintained by our great ocean barriers are regarded as just the same miles which constituted the protection of three generations ago.

Just why the popular attitude of mind which characterizes the vast majority of our highly educated professional classes prevails would be hard to determine, nor is it, perhaps, important that it should be determined. The average lawyer, the average doctor, in fact, one may say the average college man at, and for life after, graduation, regards the military service as a foreign thing with which he is unfamiliar and has little sympathy. This statement extends even to those who meet and have frequent intercourse with the officers of the Army, for such intercourse is almost without exception of a social character.

I venture to believe that if one hundred representative professional men in civil life were selected at random, they would be found, substantially without exception, to still cherish complete

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*Lecture delivered before Engineer School, U. S. A., Washington Barracks, D. C., April 26, 1911.

faith in the security of geographical isolation, in the reliability of the proverb which carries victory always with the right hand of justice, whether that hand be armed or naked, and yet more peculiarly it would be found that each one of these generally well informed and educated men, at heart, felt absolute security arising from that peculiar national egotism which has found its excuse for the last fifty years in our enormous numerical strength and our apparently inexhaustible wealth.

If one should find among this hundred cultured men one or two who did not share these views, he would probably be found to be that most painful variety of American, a jingo, than whom, I venture to believe, there are few more harmful influences in relation to national military progress.

Disavowing very definitely all jingoism, even in its mildest forms, granting definitely that a great war at any early time is most improbable, but contending, nonetheless, that peace by contract and treaty is an unstable thing and has been so in all history, a thing upon which no sane and honest person may rely; some few men of that civil life profession most nearly allied to that of the soldier have given some thought to our national conditions, from the standpoint of scientific preparedness, just as every educated man must give consideration to any measure of insurance which he understands.

The professional engineer in almost any of his specialized forms is, broadly speaking, more nearly a ready-made tool, available for military purposes, than any other citizen.

Speaking as a civilian engineer whose pastime study since boyhood has been the scientific side of the military profession, it seems to me important to the future security of the nation that the very large body of trained civil life engineers of the United States should be brought: *first*, into a condition of appreciation of what the military establishment is and is doing; *second*, to a realization that modern warfare is, broadly speaking, nothing but a carefully conducted series of engineering projects; and, *third*, into the closest possible touch, of spirit, cooperation, and even participation, both in the purpose and the results obtained by the Army's technical branches.

In every other nation of the world of which I have knowledge, the engineering professions of civil life are in definite cooperative relation with the Army. This is particularly true in Japan, in France, and in Italy, and, surprising as it may seem, in Great

Britain. In Switzerland, in Holland, and in Norway, and probably two or three more of Europe's so-called "minor nations," whose organized military establishments are, however, many times larger than our own, we find a large reliance for technical, and especially engineering talent, rests upon men whose daily peace-time avocation is purely civil.

The Japanese engineer officer, who conducted the mining operations on the face of 203-Meter Hill, is the chief engineer of one of Japan's largest mining corporations.

The colonel of England's reserve regiment of electrical engineers is a conspicuous figure in England's electrical engineering industry. He is available for military counsel in his specialty, but he is no burden upon the establishment, and can not be so except under conditions of emergency.

I have in mind a French civil life engineer, conspicuous in his own rather narrow specialty, and so engrossed in definitely commercial activities as to have essentially no leisure for any purpose, who is, nevertheless, a definite cog in the wheel of military reserve, and a conspicuously valuable aid in the special work of that branch of the service to which his knowledge most definitely can be helpful.

With this preamble I venture to assert that we need in the United States of America:

First. Definite and sympathetic cooperation between civil life engineers and the Army, and,

Second. We need a technical reserve to the Army.

COOPERATION

Abandoning false modesty, I think that we may venture to boldly assert that we have more engineering talent in the United States than has any other nation, and I think we may couple with this the statement that the great body of engineers in whom this talent is vested are quite as patriotic, quite as ready to make personal sacrifice for the common good, as is any similar group in any other nation.

The trouble lies in the fact that the idea has never occurred to them, and should it occur to them, they would not know how to go about it.

It is my hope that this condition may be completely changed by the presentation of the needs of the situation to the great national engineering societies, and through them to their membership.

Once attention is definitely attracted to the existing situation in this way, there should be little difficulty in establishing an enormously powerful national general committee, comprising civil, mechanical, mining, sanitary, and electrical engineers, whose function it should be to give cooperation, attention, and consideration to the military establishment in its technical branches, with a view to affording national support, advice, and even, I am so bold as to believe, specialized national guidance.

Whilst the men of civil life and the men of the service would be slow to admit it, I think that it is definitely true that neither class or group understands the other. Once let this condition, not of misunderstanding, but of *lack* of understanding, be wiped away, the cooperative condition will speedily follow.

Whilst the cooperative relation is probably more important as a national issue than the more concrete project of a technical reserve, it can not probably be stated to advantage in any more definite way at the moment than as I have already stated it.

The project of a technical reserve, however, can be presented very concretely.

The plan which follows may be all wrong; I shall be content if it is found to be so. It is necessary that the lump of modeling clay, from which a perfect image is to be evolved, should have some three-dimensional form when it is placed upon the modeling table, and I present the plan which follows merely as a crude mass of material, to be shaped and dealt with by those more able to assail the task, but nevertheless as at least material for a beginning.

Assuming as an axiom that any adequate plan for national military preparedne-s must contemplate the provision of an effective military force of 500,000 men as a first field army; accepting as a second axiom the substantial certainty that our form of national government, the character of our population, and the temper and understanding of our educated classes will not tolerate a large standing army, we have, as an oft-considered problem, the method of immediately creating out of private citizens a military force in addition to the existant regular establishment of not less than 400,000 men, of whom the national guard, under the Dick Bill, should theoretically provide 114,000, of whom, however, some 1,700 would be generals or general staff officers, two-thirds of whom I prefer not to count.

Effectively, I presume that the national guard would yield from 80,000 to 100,000 men.

I have no intention to deal with this greater problem, the creation of a new army of 300,000 or 400,000 men, without delay, from free-thinking and free-acting citizens; it has been dealt with fully and often by many better men. One phase of it has not been dealt with—that is, the provision of technical branches.

A field army of 500,000 men requires, according to the best European standards, not less than 2,000, and perhaps more nearly 3,000, officers whose duty will require them to be primarily engineers. I refer to engineer officers, ordnance officers, signal corps officers, and a considerable proportion of officers of the quartermaster's department; railroad, transport, equipment and repair officers, with functions innumerable of an engineering kind.

In our regular establishment we have, roughly, 180 engineer officers, 70 or 80 signal corps officers, a large proportion of them detailed from line branches, some 70 ordnance officers, also largely detailed from the line branches, let us say 150 officers, either of the quartermaster's department or engaged in similar activities in their regimental organizations, whose functions are in large measure the functions of an engineer; a total for the regular establishment of 450 to 475 officers qualified in engineering practice.

This number is really high, I have counted it and stated it with over-liberality, for the sake of conservatism.

It may be commented at this point that the officers of the coast artillery and the field artillery have not been counted; this is quite true, and the reason for the omission will be stated presently. It is also true that the needs of these two branches have not been counted in the estimate of 2,000 to 2,500 engineering officers required.

Speaking literally, if there are 475 officers in the regular establishment doing engineering, then it will be necessary to find in the national guard or in civil life only 1,500 to 2,000 technical engineering volunteer officers, but to make such an assumption seriously would be unwise.

History tells us that technical officers of the regular establishment are almost without exception highly skilled in all branches of the soldier's profession. History also tells us that a very high percentage of those men disappear instantly from their peace-time field of specialized activity, to take greatly advanced rank as line officers with volunteer troops when war comes.

If, therefore, our regular establishment at the moment has 475 officers who are qualified engineers, I venture to assert that it

would have less than 200 such officers sixty days after the initiation of a first-class war. To be sure they would not lay on the shelf their engineering knowledge and training, but they would be using it only in a manner incidental to their purely military functions. They would cease to be specialists.

Is it not fair to conclude, therefore, that the creation of a first army of 500,000 men carries with it the definite problem of finding 2,000 technical engineers who are officer material?

I have studied the subject sufficiently to feel justified in asserting that this is the case.

I referred just now to the neglect of artillery officers in my figures: I recognize instantly that essentially all artillery officers are engineers in the civil life acceptation of that word. I do not forget, however, that field artillery is our weakest arm, from the 500,000 men standpoint, and that of all the line branches this would of necessity absorb the largest proportion of technically minded officers of the regular establishment in its expansion, and the needs of this branch would, in my opinion, more than absorb all of the possible margin of artillery officers available several times over.

Problem: To find 2,000 civil life engineers, and to make them into officers capable of dealing with an active army's technical problems quickly.

Our national history tells us how we have done this in the past. To use a common railroad engineer's phrase we have, as a nation, "made them on the job." I think I speak by the card when I say that a major-general of the Civil War, who, up to a short time previous had been a lawyer, said, when asked who should be appointed engineer officer on a certain staff, "Appoint anybody who wants the job, if he is not qualified he will disappear."

Looking the matter squarely in the face, it is this very policy, perhaps I should say national tendency, which has resulted in the cost of the military establishment equalling or exceeding that of the great military nations of Europe, whilst our active Army, reinforced by all of the organized militia is inferior, numerically, to that which Servia, with two and a half millions of people, can put into the field. The balance of our national expenditure goes to pay the pension rolls, which I venture to believe have come into existence quite largely through the national tendency in times of peace, which has rendered it essentially unavoidable in times of war to appoint, initially, to positions of military trust, a very large num-

ber of people who have little or no other claim to such appointments than influence and serious need of employment.

With all self-respecting Americans, I share the firm conviction that we are peculiarly rich in military material, measured by what might be termed the physical and moral qualifications.

With our present quality and quantity of population I believe that it would require a war of extraordinary magnitude and length to bring us to the necessity of any other basis than that of voluntary service, and the supply of generally well educated men is so great that there will be no lack of excellent volunteer officer material, except in what might be termed the specialized services.

History makes it clear that we can not hope to provide this 2,000 odd technical officers by the hasty and chance enrollment following a first call for volunteers. The material which comes forward under these circumstances is distinctly line material; the early volunteer officer material aspires to go where it can participate in the greatest possible amount of fighting in the least possible time, and even if some proportion of these eager volunteers are qualified by education for the technical branches of the service, they have been shown to prefer line service under such circumstances.

The really well qualified technical engineers in civil life who are engrossed in civil life activities, are unlikely, or have been in the past slow to figure conspicuously in any early volunteer movement. This is not due to any lack of patriotism on their part, but to long training, which has taught them to ponder before acting.

The net result of this national situation has been shown in the past, and probably would again prove, to result in the assignment of the less desirable volunteers to a considerable proportion of the specialized technical posts, and under this old method a successful organization has resulted only after a long and disastrously costly process of eliminating the unfit.

To provide a well-defined peace-time force of technical emergency officers three alternatives seem to present themselves.

First. The provision of a vastly disproportionate number of regular technical officers, actively attached to the permanent establishment. Such a plan would probably be ideal were it possible. There needs no argument, however, to convince anyone who has studied the military history of the United States that it is obviously necessary to disregard this possibility; even if it were not impracticable, it probably would not prove good in the try-out, for even if we could provide and take care of, in time of peace, an

extra force of 2,000 specialized technical officers, at the first outbreak of war they would disappear from that particular sphere of activity like snow in springtime, reverting instantly to high ranking positions with volunteer line troops.

The *second* alternative lies in the national guard.

Those military students who condemn the national guard as inefficient and not a true reliance, have, in my opinion, failed to closely watch and study the progress of the past ten years. If the rate of improvement of the last decade continues, the national guard of the United States of America will in a relatively brief period of years be, without question, the best citizen soldiery in the world; but the nature of the organization, the very fundamentals of civil life upon which it rests, make the development of specialized technical branches under national guard auspices particularly difficult of accomplishment, if not impossible.

The men who throw themselves by choice into amateur soldiering commit themselves, open-eyed, to a large obligation of police duty, and accept this burden in exchange for certain of the more romantic sides of soldiering which, superficially at least, are less intimately associated with the technical branches.

In short, I believe that the organized national guardsman is essentially a line soldier.

For technical service purposes the men who would be really desirable are not found in any considerable numbers in the national guard. They may be selfish, though I believe that they are not unpatriotic, in their shirking of the obligation of police duty.

The men we want in the technical branches for the emergency are essentially busy men, engaged in big affairs; if they were not so we probably should not want them.

We find, therefore, that such state troops as are organized into technical units, engineers, signal corps and the like, compare far less favorably as *technical troops*, and as technical officers, with the regular service, than do selected bodies of state troops of the line, with regular line troops and officers.

I have in mind one splendid body of state troops who are organized as and known as engineers. The officers are well educated gentlemen without exception; it would be my personal judgment that they are exceptionally good, surprisingly well trained infantry; I gravely doubt whether any appreciable number of the officers would prove to be engineer officers under war conditions. I do not make this statement disrespectfully; I believe that the

divergence of these men from engineer duty would be as much a matter of inclination as of disqualification.

The *third* alternative is that which I am venturing to advocate, only for lack of a better plan.

Let there be established under each of the technical branches of the regular service a body of civil life reserve officers of the regular army; let these men be selected and commissioned under a searching system of investigation and examination. Seek them in those civil life vocations where each of the specialized educations required is most likely to be found; burden them with a minimum of formal military training; and hold them in reserve for the emergency under just sufficient periodic examination, just sufficient prescribed military reading, and just sufficient general supervision to preserve them as an efficient emergency resource.

It may be contended that men of high standing and reasonably mature years could not be induced to participate in any such program. I believe that a trial of the plan would prove this argument fallacious for at least two reasons: *first*, I believe that men of high standing and ability are no more lacking in patriotic impulse than the average run of mankind, and *second*, I believe that to this may be added a sharp incentive of self-interest.

In the try-out I believe that it would be found, in the case of a municipality, for example, requiring an engineer to design and supervise the construction of a bridge, definite preference would be given, other things being equal, to the man who had received the endorsement implied by a reserve commission, under a properly organized system of investigation and examination.

It might be contended on the other hand that this body of men would be so utterly lacking in the rudimentary knowledge of military routine, parlance, and custom, as to be quite useless for military purposes, however great might be their ability professionally. The answer to this is obviously that they could certainly acquire this necessary knowledge quite as quickly as any other volunteer, selected by a haphazard method, and these men would at least be fortified by careful and diligent pursuit of prescribed reading, which would prepare them in theory for what they might some day have to practice.

Great Britain may not stand high as an example of what should or should not be done with land forces, but she probably does stand preeminent as the best possible reference as to what should be done in naval policy, and we all know that a very high propor-

tion of the higher grade merchant marine officers sailing under the English colors are reserve officers of the British navy, ready for the emergency, each man of record as to ability and standing, each man not only available but qualified, save in the more formal essentials.

To be specific, one should, under the system here suggested, seek specialized engineering officers among civil engineers of repute and high standing, among the engineers of the great railroads, and among the engineers of the great electrical and mechanical manufacturers. One would seek ordnance material among the staffs of the great steel corporations and the great machinery houses, as well as among the commercial gun and small arm manufacturers of the nation, and possibly even among the chemists of the great explosive manufacturers. In the quartermaster's branches one would seek men possibly in all of these walks of industry, but with special reference to their careful commercial training and qualifications; whilst for the signal corps material would be sought primarily amongst the great communication corporations, telegraph, telephone, and wireless, with some additions from those industries engaged in the manufacture of the appliances used in such work.

Regarding a few of the quite obvious objections:

PAY AND EXPENSE

It might be necessary (I doubt it) to attach some small annual remuneration to each reserve commission, in the same way that retainers are granted in civil life to men of similar standing. Even if this proved necessary, it would be a small monetary burden as compared with the insurance secured. I should, however, be gravely disappointed if such a measure proved to be necessary to the success of the plan; the indirect reward should have sufficient value.

In time of active service, pay and allowance would obviously be identical with those of any volunteer officer, however secured; no burden or obligation lies here.

TRAINING AND MAINTENANCE

It would not be the primary purpose to make soldiers, but rather to provide fit technical material. To make these men quickly available, prescribed reading would be necessary, and possibly a system of infrequent staff and routine detail for very brief periods; the point, however, of the provision of suitable material is the crux of the argument, and should not be permitted to be hidden by any objection of inadequate military training.

THE QUESTION OF RANK AND COMMAND

On a reserve basis it would not seem to be necessary to give these men really high rank, nor would I suggest for a moment that they be given a stripe on their trousers. Granting that a certain proportion of these men would, in the emergency, have to command troops, it would seem to be simple to make it inherent in the system that with a detail to the command of troops *they would cease to have official connection with the reserve*, and would forthwith literally become volunteer officers on exactly the same basis that volunteer officers always have and probably always will be created.

It seems to be inherent in our system, personally, I think very regrettably inherent, that a considerable proportion of citizen officers in any war will start out ranking professional officers of the regular establishment, whose whole lives have been given to a study of their profession. In principle I believe that this is bad, but we are dealing with a condition, not a theory, and if this condition is to obtain, I believe that all will concede that it would be better in the technical branches that such men should at least have high qualifications, and be of high standing, than that they should be selected and appointed almost by chance.

MAINTENANCE OF INTEREST AND ENTHUSIASM

Here we must fall back upon the hackneyed theory of natural elimination of the unfit, nevertheless it is thoroughly true that it is better that this process of elimination should go on in times of peace than in the presence of the emergency. The men who could not maintain interest and enthusiasm would not be the men whom we should want as reserve officers, and they would disappear by self elimination and would be progressively replaced by more fit material.

A certain large measure of interest and enthusiasm might well, however, be maintained by the detailing of especially well qualified men from the reserve branches to all kinds of advisory boards.

No civilian who has studied our organization even superficially can fail to be as much surprised as impressed by the extraordinary proficiency of the officers of the regular establishment in almost all branches of specialized engineering; nevertheless, the officers of the regular establishment can not, with very rare exceptions, hope to be anything but what the medical profession would term "general practitioners;" they can not, broadly, be specialists in electrical, mechanical, or other separate branches of engineering; never-

theless the service has great need, from time to time, of the advisory aid of such specialists, and such aid would be found to be forthcoming in a properly organized reserve corps such as suggested, and this, while directly beneficial, would also be indirectly beneficial, as a means of maintaining sustained enthusiasm and interest.

At this point it would be appropriate for some one to suggest that, if we need a reserve of 2,000 technical men who are officer material, we also need not less than 15,000 men as reserve technical troops.

This is perfectly true, and it is also probably true that this presents a harder problem for peace solution, and an easier problem for war time solution, than the question of officers.

It is always easier to find a working force for the building of a bridge than to find the engineer and the foremen. Men have done, and men will do, pretty well on this kind of a job with unskilled labor, and with considerable rapidity will convert unskilled labor into skilled labor. To tackle the building of the same structure with an engineer and with foremen who had to be trained and created on the job is a hard proposition.

Nevertheless, given a reserve of technical officers such as is suggested, it seems fair to believe that a plan would be speedily evolved for the creation of at least a skeleton reserve of technical troops; such a skeleton establishment perhaps as that which Switzerland has for her entire military force; groups of men rising perhaps to the degree of organization which might be termed cadres, located particularly in the great industrial centers, and affording, at least, preferred material for non-commissioned ranks, and a rallying center for quick recruiting, guided more or less by the definite acquaintance of the reserve "non-coms." of the cadres.

Probably this system, in its earlier stages, could not be as systematically organized as the officer force, but it could doubtless be evolved into something efficient and useful and without expense.

There is one curious national strain in our race which I venture to believe we enjoy to a far greater extent than the people of any other nation; it might be termed a kind of military hankering, which most Americans of all classes would be glad to indulge if they could do so by the acceptance of some established system.

I have heard it said that every healthy American believes himself capable of becoming an effective general, and that nothing prevents him from feeling that he might become an effective admiral, save the fear that he might be sea-sick.

I have heard this statement presented time and again as a humorous criticism of certain national traits; may we not, however, turn it to serious good in connection with a propaganda such as is here presented?

I admit freely that I have laid before you a plan both crude and daring. It is at least presented with enthusiasm—not with any idea that the plan as here presented can or will be adopted, not with any idea that the thoughts presented are original, but with a deep seated hope that these suggestions may be materially helpful in crystallizing a really good plan, equivalent in purpose and in result to the intent of the thoughts which I have laid before you.

DISCUSSION

Col. F. V. Abbot

Corps of Engineers

Mr. Haskins' suggestions for a technical reserve for the Army are carefully thought out, and open up for consideration a most important practical problem. For the Cuban war in 1898 three regiments of volunteer engineers were rapidly formed, and were officered without difficulty by men who were well fitted to do credit to the service had there been any real military engineering to be done. My experience is limited to one company, which was raised in St. Paul, Minn. Its captain was A. O. Powell, the principal assistant engineer in the river and harbor district of which I was in charge. The non-commissioned officers included the draftsman of the United States Engineer Office, and a number of young men engaged in well paid positions, as foremen in the gas and electrical companies outdoor working parties, as lumber foremen, as railroad section hands, etc., while the enlisted force covered all the technical branches of trade. Surveyors and rod men, telegraphers, electricians, steam engineers, locomotive engineers, blacksmiths, mill men, machinists, plumbers, masons, carpenters, timber cutters were all represented. It would be hard to organize a better force for a general contractor than was represented by that company.

On the return from their bloodless campaign in Alabama I was glad to employ as foremen and journeymen many members of this company, and to the credit of the patriotism of the people of St. Paul it should be said that with few exceptions the men who had given up their positions to join the company were reinstated in their old positions on their return.

This brings up one vitally important point. Would men of technical training give a pledge which would bind them to quit without delay whatever work they were doing, without reference to the interests of the persons by whom they were employed? Would em-

ployers entrust men so pledged with the supervision of important and costly work, interruption of which might easily entail direct and unavoidable losses? This is the weak point in our whole militia problem. The best men in the community are willing to give their time and energy to develop the *local* militia, which is the "secular arm" on which the police must rely in civil disorder beyond their power of control, and which is to serve within the limited area of a single state, but they hesitate to become full volunteers in time of peace to bind themselves to serve at an *indefinite* time, and for a cause which may or may not meet with their personal approbation. When real need arises, when they know definitely what they are doing, why they are doing it, and when they must volunteer or stay behind, such men will offer their services to the Government. History has proved this. That the most desirable and reliable class of technical men will bind themselves beforehand, in the dark, and in utter ignorance of where and when they may be called upon to serve, seems extremely doubtful. If the positions as commissioned officers are filled beforehand with men, not the most desirable and reliable, but only thoughtless and enthusiastic, the technical troops actually raised will lack the most important of all factors to success—a commissioned personnel of sound judgment, broad intellect, and wise forethought.

Mr. W. F. Wells

The writer concurs with Mr. Haskins that considerable advantage would accrue from a more definite cooperation between the engineers of the Army and those of civil life, and from an organization of a technical reserve to the Army.

Cooperation would give the Army engineer the advantage of the experience gained by a civilian engineer in any highly specialized class of work, which experience has been obtained through experiments and work extending over a number of years and requiring a large and expensive plant and organization. As the ultimate work of the Army is not constructive, but either destructive or defensive, the Army engineers have little to give in return that would be appreciated by those in civil life. As a rule, constructive engineers in this Republic care little for title or honor, and therefore, in time of peace, the advice and experience of those best fitted could probably be obtained only by means of a retainer. Engineers are as patriotic as any other class, but would not be expected to give away valuable time and services any more than a merchant would furnish supplies to the quartermaster without charge.

With regard to the technical reserve, the civil life engineer, holding an administrative position in a large company, has by virtue of such position an excellent opportunity to select men for the work of the engineer corps; his broad acquaintance enables him to quickly collect the requisite number of men fitted for any con-

struction job, and his training has specially fitted him for organizing such men, equipping them with the proper tools and obtaining the necessary supplies with which to do the work.

These opinions are based on a very slight acquaintance with the work of the Engineer Corps of the Army, obtained from the public press, casual observations at posts and one or two definite instances.

One of these occurred during 1898, when a rumor was circulated that Admiral Cervera was about to attack New York City. The company with which the writer was connected had consulted with the Government representatives regarding ways and means of rendering assistance if needed.

On Saturday, April 2, 1898, word was received to leave New York Tuesday, April 5, at 8 a. m., and report to Lieutenant Raymond, Fort Wadsworth, Staten Island, with men, tools, and supplies, and proceed with the installation of submarine cables to be connected to mines located in the Narrows. I selected a superintendent and two foremen who had long experience in handling and laying underground and submarine cables in and around the city and harbor of New York; a tester and galvanometer expert who had been trained in testing submarine cables in both the Atlantic and Pacific oceans as well as short cables in harbors, and in addition had done underground cable testing in New York and other cities. The other ten men were chosen on account of their ability as riggers, carpenters, jointers, plumbers, and wire men, all trades which are required in the proper handling and laying of heavy insulated and armored cables. This work requires delicacy in handling the conductors, absolute waterproof insulation of joints, and mechanical strength to withstand strains incident to handling and laying on the rough and unknown harbor bottom.

Before starting, information was obtained from the cable company which had furnished the cable as to its exact character, and a complete equipment of tools, instruments, supplies necessary for supplying and joining the cables was loaded on a large truck and sent with the men. These supplies and tools were sufficient to do the work without depending on any jointer's tools or supplies which might be found with the quartermaster at the fort. It so happened that the supplies found there were unfit for our use, the pure rubber gum being completely dried out and the other supplies not suitable for this class of work. With the exception of the knives, the tools found were unfitted for the work.

We arrived in a driving snow storm and placed ourselves at the service of Lieutenant Raymond. After a consultation with a representative of a lighterage company, who had reported in response to a similar call with a steam lighter and crew, it was determined that owing to stress of weather no mines could be located that day. The day was well spent, however, in preparation for work and obtaining quarters outside the fort for the men.

On the next morning the work was started, and completed within a short time to the satisfaction of the officer in charge.

This incident is cited merely to show the advantages a civilian engineer has for specialized work, and how such might be of benefit to the Government.

Mr. LOUIS BELL, Ph. D.

From the standpoint of the civilian interested in national defence Mr. Haskins' paper seems eminently practical. Without doubt our own country for various reasons is peculiarly hampered in making preparations for emergencies.

In the first place, while on the whole a patriotic people, we are far from being a martial people, and the profession of arms has been looked on as perhaps an honorable one, but yet not quite worthy the serious attention of one who could more profitably devote himself to business or to ordinary professional pursuits. More than this, we have a pretty thoroughly ingrained dislike of an adequate military establishment, due primarily to ancient heritage, but secondarily to "pound foolish" economy, and beyond this we have a loose democratic form of government which is admirably adapted for times of peace, but operates with so much "back-lash" as to be terribly wasteful of energy in time of emergency. I think many military men will agree with me in the opinion that with a government constituted as is ours, and a press which is absolutely beyond control except in the dire exigency of martial law, we require for equal results in national defence something like double the armed force that would be necessary to carry to a successful conclusion the same operations in the case of a more closely organized and unhampered central government.

Consequently, it seems to me that suggestions for a trained and available reserve, particularly in those branches of the service in which much technical experience is necessary, are important and must be taken very seriously. In case of war with a first-class power every available officer of the regular service, active or retired, would be needed immediately in the field; not for his regular duties, but for the terrific task of building up an army at short notice out of material brave and resourceful enough, but almost entirely untrained.

Mr. Haskins' suggestions ought to go far toward providing a reserve available at once and fully capable of taking up a large amount of work well within its scope of successful accomplishment, thus freeing the regular establishment for more urgent necessities. I believe, too, that the organization of such a force would serve an extremely useful purpose in bringing a capable and influential group of civilians into closer touch with the military establishment and into greater sympathy with its aims and efforts.

Our experience in the emergency of the Spanish War certainly showed that large and important work in coast defence could be successfully carried out by an engineering force without previous military experience, depending solely on its intimate knowledge

of the purely technical requirements of the situation. If such a force had been in regular contact with military affairs for even a year or two it would have been enabled to take up work of a wider scope and to prosecute it more energetically. Our experience of that time proved that it is easy to get a working force of volunteers for technical operations of a grade a good deal better for this particular service than can be obtained among men enlisted in time of peace. It seems to me that Mr. Haskins' practical suggestion of forming a group of reserve officers for emergency work is a thoroughly practical one. Just how it can best be done those who have been trained in the service can tell far better than any civilian. From our brief experience in 1898 it seems to me, however, that the thing most to be desired is a body of reserve officers sufficient in number to take up and carry on the technical tasks of military work, and trained by constant contact, which ought to be helpful to both, with the officers of the regular service. If a reserve group of officers, capable of taking up the various technical requirements of military operations, could be formed near each regular post it would be comparatively easy to give it valuable military training through the efforts of the regular officers there stationed. It would be possible, for example, to train reserve officers in the routine necessary in military service and to familiarize them with the work actually being carried on. Periodical gathering with the regular officers in a sort of Kriegseminar would very soon transform good material from civil life into officers capable on very short notice of taking up military engineering and technical military work generally with a good degree of efficiency, good enough in fact to release in time of need the regular officers for service in the field without lowering the efficiency of the local work for defence.

It would be still better if such reserve officers could be called into service even for a very brief period each year and assigned to different ground on each tour of duty, so that there might be available a body of technically trained officers personally familiar with the exigencies of defence work; for example, all along the Atlantic Coast line. With a few years of training of this sort it should be entirely feasible to have a reserve for which a definite scheme of mobilization could be organized, so that its officers in case of need could drop into places already made familiar and take up work for which they had already been trained. The advantage of such a force in time of war and particularly in case of the sudden call to arms, which is now the rule rather than the exception, strikes me as self evident.

Capt. LYTLE BROWN

Corps of Engineers

Mr. Haskins speaks of "general practitioners." That strikes me with force. The engineer officers with the active field army must

indeed be "general practitioners," expecting any disease for diagnosis. Yes, "country doctors" would be better. They can not carry much medicine in their saddle bags—only a knife, some calomel, some quinine, and a little bottle of castor oil—but each must carry a peck of brains in his campaign hat and a ton of backbone in his khaki shirt.

Brig. Gen. IRVING HALE

United States Volunteers

Mr. Haskins' suggestion for a technical reserve for the Army is timely, well considered, and forcibly expressed.

Having served in the Regular Army, national guard, and volunteers, and for years followed the more or less peaceful pursuit of electrical business, I feel a cordial sympathy with all branches of our military system, as well as the ordinary civilian, and can appreciate their strength, weakness, and relations.

As Mr. Haskins intimates, the American people are not unfriendly, but rather indifferent to, the Army, and inclined to belittle its value and absolute necessity. Nine men out of ten, in personal discussions, will admit that preparation for war is the best insurance for peace; that our Regular Army, fine as it is in quality, is pitifully small; that our militia and arrangements for organizing a large volunteer army are absurdly inadequate; and that in case of conflict with a great nation we would be up against a desperate situation. And yet those same intelligent citizens, imbued with American over-confidence, not to say bravado, will ignore these arguments, trusting that in any emergency Yankee luck, pluck, and ingenuity, coupled with a strong pull with Providence and the justice of our cause, will carry us through.

Except in individual cases, the Army is, on principle, opposed to advertising—perhaps too much so for its own or the nation's interest. It would be mutually beneficial to keep the Army more intimately associated with the people, and the people better informed of the Army's work and objects.

Our regular and citizen soldiers are alike volunteers and patriots; and wherever they serve together on the fighting line, each takes off his hat to the other. Carping criticism, on either side, comes mostly from those who have seen little actual service.

The technical departments of the Army are highly capable and efficient in everything they undertake. This is well exemplified by the splendid administrations and progress of the Panama Canal under Army engineers. And we hear nothing of their quitting—they are on the job to the finish, unless properly relieved.

But, as Mr. Haskins says, the officers of our engineer and ordnance corps are so highly qualified in all military lines that they will be drawn upon to command volunteer regiments, brigades, and divisions, and those remaining in their own departments will be insufficient, except for the higher positions. Moreover, these men,

able and well informed as they are, can not be specialists in all lines, such as railroad and electrical engineering, and must call to their assistance men thoroughly versed in those directions.

On the other hand, it would not be easy to secure such engineers promptly from civil life or volunteer regiments in time of war. The volunteer "enlists to fight." He willingly and enthusiastically builds camps, roads, bridges, and intrenchments as incidents to getting on the firing line; but he has little taste for these necessary evils straight. The fact is overlooked, both in the regulars and volunteers, that engineer troops do about as much fighting as anybody; but it is so covered up by their other duties that the glory disappears.

Mr. Haskins is probably right that the national guard organization and methods would not especially appeal to most engineers; and they are usually too busy to spare the time from their regular work.

His idea to attach them, as a reserve, to the regular establishment, seems practicable, and perhaps the best alternative. They could and probably would be willing to devote the necessary time to study and periodical examinations to familiarize themselves with military requirements. They could serve on boards as specialists; and such duties would justify some reasonable regular or specific compensation. The reputation of belonging to such an organization would, in itself, be an inducement and professional assistance.

Such a plan would have various advantages. First, it would bring an intelligent and influential class of citizens (and, through them, others), into knowledge of the Army and its methods and characteristics. Second, it would put the Army in closer touch with the people. Third, the Government would receive the benefit of specialists in time of peace at moderate expense. Fourth, this reserve corps of trained engineers would be on tap in case of war or any other emergency.

Lieut. Col. J. E. KUHN
Corps of Engineers

Just a year ago it was my privilege to listen to a lecture by Mr. Haskins on the same subject, delivered before the Army Signal School at Fort Leavenworth, Kansas. His professional standing, as well as his actual experience during the Spanish-American War, in connection with the submarine mine defence of Boston Harbor, lend a special significance to his suggestions for the creation of a technical reserve for the Army.

That a technical reserve, such as proposed by Mr. Haskins, would render incalculable service in a great national war must be self evident to every thoughtful American, more especially to the professional soldier. War, like all other forms of human activities, is becoming more and more a matter of the application of the technical arts and sciences. The soldier on the firing line is merely the final consequence of a vast and complicated series of operations

involving the solution of numerous problems closely related to the technical arts.

Perhaps this may be put into a more concrete form by considering the daily requirements of a city of half a million inhabitants. Consider such a city with all its inhabitants in a body, constantly moving about in a considerable area, and reflect on the varied problems of transportation, communication, supply, and sanitation calling for solution. These problems are such as our highly trained men in the technical profession are eminently fitted to handle and whose services will inevitably be required in a great national emergency. That these men will respond to the needs of the nation is certain, and that they will quickly adapt themselves to the requirements of military service is equally certain. The education and training of men engaged in the various fields of engineering are such as to inculcate habits of loyalty, subordination, and zeal; in other words, discipline, so that they will fit into a military organization more readily and quickly than men of other callings.

But it is not enough to know that technical men in abundance will offer their services and that they can be quickly fitted for military requirements. The conduct of modern war admits of no trifling with time, and if time is to be saved and confusion avoided it is important that some definite and logical plan be formulated, with a view to its serving as a basis of action.

What plan, then, can be formulated for utilizing the able, patriotic, and manifestly necessary technical services of that large body of highly trained technical men on the outbreak of war? Mr. Haskins suggests, first, definite and sympathetic cooperation between the Army and the civil life engineers and, second, the creation of a technical reserve. With regard to the first suggestion, cooperation is unquestionably a most desirable element, but how to insure sympathy and recognition of mutual interests in times of peace, that is the question. As Mr. Haskins points out, lack of understanding is chiefly responsible, but how to obviate this lack of understanding? Upon whom should devolve the responsibility for establishing closer relations between the Army and the technical professions? Manifestly, this is a difficult problem.

If we had more men in civil life of Mr. Haskins' mental attitude on the subject the desired end could soon be attained, even without any effort on the part of the Army itself, but the general apathy, I might even say disinclination, toward all things military leaves little hope in this direction. If a better understanding is to be brought about between the Army and the civil technical professions, the initiative should be taken by the Army, but in just what form is problematical. Possibly a presentation of the needs of the Army from the heads of the several bureaus of the War Department most interested in technical matters to the heads of the great technical societies might be the means of breaking the ice and eventually bringing about the desired results.

With regard to the establishment of a technical reserve, the problem presented takes on a more tangible form. Furthermore, such a reserve, once started, would help toward bringing about that sympathetic understanding which is now wanting. The creation of such a technical reserve is a comparatively simple matter and easily effected by proper legislative enactment. All that would be required would be authority for the formation of the desired number of reserve units for the various technical services, such as railway battalions, signal battalions, transportation battalions, aeronautical companies, etc., in which commissions and warrants should issue to competent technical men for a definite term of years. These appointments should carry with them some material emoluments and obligate the incumbents to a prescribed course of study and training having in view strictly military requirements. It is believed such a system can be worked out in its details so as to be sufficiently attractive to technical men in civil life and profitable to the Government.

With a nation possessing such an abundance of excellent military material and such boundless resources, it seems a pity that we should habitually leave so much to chance on the outbreak of war, and all for want of a little forethought. The creation of a technical reserve is but one of many things that could and should be planned for and carried out in advance. The cost of such a reserve could be kept to an almost nominal figure while the benefits could not be measured in money.

Mr. JOHN STEPHEN SEWELL

Late Major, Corps of Engineers

The writer considers it a great privilege to have been permitted to discuss this very interesting paper. He could probably save time by simply stating that he is and has been for many years entirely in sympathy with the views expressed by Mr. Haskins, but perhaps a few details will not be out of order.

In the year 1898, upon the outbreak of the war with Spain, the writer, then a first lieutenant in the Corps of Engineers, was entirely responsible for the torpedo defence of Boston Harbor. He was able to secure from the regular establishment the service of four enlisted men familiar with the submarine mining work. The project called for something like two hundred and fifty submarine mines. Mainly from the Engineer Depot, or partly as a result of local purchases, the necessary materials were secured for the execution of the entire project. The question of personnel, however, presented an extremely serious "deficit." The writer, under instructions from the Chief of Engineers, began to look around for means of supplying this want. He went to the offices of the General Electric Company and there met Mr. Haskins. Mr. Haskins enthusiastically volunteered to assist in every way in his power. In a very short time he had together an extremely

efficient organization of two or three hundred members, including engineers of distinguished ability and high class mechanics in every line of work which would be useful in carrying out the submarine mining project. The writer, in connection with this work, congratulates himself upon having had the judgment to point out what was required to Mr. Haskins and his organization and leave them to do it, which they did promptly and efficiently.

The writer believes that this Boston organization really served as the model for similar organizations in other cities. Of course, their work was not submitted to the test of actual combat, but the writer is convinced that it would not have been found wanting had such a test been applied to it.

As a result of this experience the writer discovered that there was a vast possibility for sympathetic, mutual understanding and cooperation between the technical branches of the military service and technical men outside. In fact, he believes that many of the most valuable improvements that have been made in the submarine mining service since the Spanish War can be traced directly back to the interest aroused in this subject by the organization of this "volunteer electrical corps" as we have always called it, in Boston Harbor. Mr. Haskins says that modern warfare is, broadly speaking, nothing but a series of engineering projects. With this statement the writer is in thorough accord, and has been for many years. In fact, the art of war might be defined as merely a special application of the entire science of engineering in all of its branches. The writer, having been both in the service and out of it, takes the liberty at this point to suggest that this view of war will be harder for the engineer in civil life to grasp than it is for the members of the technical branches of the service. Once the engineers in civil life grasp it, however, the writer is convinced that much unnecessary criticism and friction, which have existed in times past, will promptly disappear, and the personnel of the technical branches of this service, instead of finding captious critics among their brothers in civil life, will find extremely valuable and sympathetic supporters and advisers. Mr. Haskins is again entirely correct in saying that while the men in the technical branches of the service are undoubtedly proficient in all branches of engineering, they can rarely hope to specialize on any one branch to the extent that is possible for engineers in civil life. The writer knows from his own personal experience as a "general practitioner" of what extreme value the advice of the highly trained specialist often is in purely military application of the science of engineering. The writer is profoundly convinced that the realization of the objects set forth in Mr. Haskins' lecture would do more toward strengthening the military position of this country than almost any other one thing that could be conceived. A well trained engineer is, as Mr. Haskins well says, not only a ready made tool, but an extremely good one. During the writer's experience as a field officer in the First Regiment of Volunteer Engineers during the war with Spain,

he found that the well-trained engineers from civil life who came into that organization fell into the military way of doing things almost as by second nature. Their previous lack of familiarity with military affairs and procedure amounted to practically no difficulty at all. Mr. Haskins' remarks on this point, point out a difficulty which is sure to vanish into thin air the moment it is really encountered.

As for the details of organization of such a technical reserve as Mr. Haskins described in general terms, that is a matter which the writer believes will automatically straighten itself out the moment the work is undertaken. The writer also believes that there will be no great difficulty in organizing and maintaining a technical reserve of enlisted men as well as officers.

The writer, as stated above, is so completely in sympathy with Mr. Haskins' ideas that discussion of the lecture itself seems to him almost superfluous; if he has any criticism to offer it is that all of the difficulties hinted at by Mr. Haskins really do not exist at all, or, if they do, they would melt away immediately upon the inception of plans for forming the technical reserve.

Col. W. M. Black

Corps of Engineers

That our Regular Army is entirely insufficient in size to meet the demands that would be put upon it in case of war with even one of the minor powers of the world, is realized fully by the officers of the regular service. Recent incidents in Congress justify this statement. An undue reliance is being placed by the country at large on the aid which would be given by the organized militia. That the men composing that body are brave and patriotic is without doubt, but the conditions under which it is organized and trained are such as to make it impossible for it to become thoroughly efficient for field service without a training in actual war through a period of time longer than would be afforded in a war with any first-class power without grave losses of life and property to our country.

A very large proportion of the men now in the organized militia earn their livelihood in shops and offices which afford little or no experience or preparation for field service. To obtain this preparation and experience, portions of the militia are called into service for field training for from one to two weeks annually. Due to climatic conditions, this period of field training must be had during the summer months at a time when the civil work involving out-of-door constructions must also be carried on. It thus results that employers of labor are called upon to curtail their own work by relinquishing the services of such of their employees as are in the militia at the very time when their business requires its most active prosecution. This is no small matter. An employer may find himself seriously embarrassed in his business at a most critical

period. Is it to be wondered then that employees are discouraged from active work in militia organizations? The number of men in militia organizations will always be limited by this. This is a condition which can not be overcome by any system of militia organization and is a controlling cause why such an organization can not be considered as a really efficient resource for the national defense. This is probably one cause why so few engineers or men engaged in out-of-door construction work are found in the ranks of the militia; yet, for technical troops, this is the very class of men most needed. The efficiency shown by the three regiments of volunteer engineers during the Spanish War is a proof that the previous training of their officers and many of their non-commissioned officers as engineers, accustomed to control bodies of men in field work, goes a very long way in their training as soldiers. In questions of discipline, sanitation, exercise of executive ability and ability to meet emergencies as they arise, the field work of a modern contracting engineer and of his technical assistants parallels closely the task of an army officer in the field. A very great part of the work of a military engineer during war is absolutely the work of a civil engineer during peace.

It is my belief that sooner or later the country at large will be convinced of the relative inefficiency of the militia as an effective implement of war and that a provision will be made for the formation of a first reserve of men who have received training in the regular service. Even should this be the case, there will not be provision for a sufficient number of technical officers and troops, and Mr. Haskins' suggestion looking toward the formation of such a reserve body is worthy of very careful consideration. Generally, civil engineers are less pressed by their civil occupations during the winter months and, with the field training which they receive in their professional work, instruction in the most necessary technical military affairs could be had by them in the winter time, with the minimum necessity for summer field work. Should such a body be formed, each organization should be trained with especial reference to that branch of the work of the military service which corresponds most closely with the civil pursuits of its members; indeed, it might be possible to omit almost entirely from the instruction of many of these organizations the greater part of the purely technical military instruction required by the regular troops.

Lieut. Col. W. C. LANGFITT
Corps of Engineers

The lecture delivered by Mr. Caryl D. Haskins, on April 26, 1911, was heard by the writer, and the advance sheets have been read with equally great pleasure. That the great body politic are ignorant of and indifferent to our military establishment is unfortunately too true, and possibly a more convincing proof can not

be found than in the fact that there is difficulty in obtaining candidates for admission to the United States Military Academy, a school which furnishes such an excellent general education in addition to its military features. Some signs of awakening in this respect are observable, and the lecture under consideration is one of the most gratifying.

It is undoubtedly most desirable that the whole nation, as well as the engineering profession, should be brought into condition appreciating what the military establishment is doing; and second, to a realization that modern warfare is, broadly speaking, nothing but a carefully conducted series of engineering projects, and also that these projects are especially peculiar and that military training seems necessary to a proper understanding of them. This is admitted or shown in this paper, and it is really a proposed solution of how to get this preparation instilled in a sufficient number of educated men. The examples given of the coordination between civil and military bodies in other countries are very enlightening, and would lead us to believe that a solution of the two problems stated by the author may possibly be reached. These problems or needs are stated as follows:

First. A definite and sympathetic cooperation between engineers in civil life and the Army.

Second. The need of a technical reserve to the Army.

There seems no disputing these assertions, as they are self-evident to those informed in military matters when once stated. It may be admitted, first, that we have more engineering talent in the United States than in any other nation, and, second, that the engineers are quite as patriotic as any other body of men. It would appear, however, that the patriotism which leads to sacrifice in time of peace or even in time of war seems lacking in this country in all classes, and I am not so hopeful that the existing situation can be easily changed. At the same time there is no inherent reason why military and non-military engineers should lack mutual understanding and sympathy any more than electrical engineers should lack similar understanding of civil or mechanical engineers.

The tentative figures of the author as to the need of technical engineer volunteer officers which would arise in a large war may be accepted as approximately correct, as also the fact that engineer officers have been in the past, and will be in the future, sought for to take high commands, and thus not be available for required engineering work.

After stating his problem, viz: "to find two thousand civil life engineers and make them into officers capable of dealing with active army technical problems quickly" the author goes on to state that in the past we have, to use the railroad engineer's phrase, "made them on the job." As a matter of fact, one of the reasons why our technical branches of the Army are so small is the same old fallacy, our confidence that we are all born soldiers and that we do not have to be made, or even slightly remodeled, to become as

good soldiers as those of any other nation become by years of training and study. While there is no question but that, with our present population, volunteer service will provide the troops necessary in war, these troops will be lacking in training, and in modern wars time will be lacking in which to train them. It is also true that more training and more time therefor is required in the technical or engineering branches than in the other branches. Moreover, as suggested by the author, this volunteer material, qualified by ability and education to be trained to the technical part of the military work, would much prefer to adopt a position in the line where advancement is more rapid and where the excitement of combat is more attractive. There is no reward held out for the technical officer similar to that which is held before the eyes of the man in the line. *The moral of this would be to obtain in time of peace as large a number of technical officers in the technical branches as Congress can be persuaded to authorize.* This is the first great desideratum, and even if Congress could be induced to double or treble our present number we would be still far short of the needed supply, and some such scheme as advocated by the author would still be necessary.

The establishment of a technical reserve should be started in a small way and, no doubt, experience would enable us to develop it more rapidly and along surer lines than the first attempts would follow.

The author takes up and disposes of what he calls "the quite obvious objections." First, pay and expenses. I am personally of the opinion that some remuneration to each reserve commission would be necessary, and that during the time that they are being trained or are devoting themselves exclusively to Government work they would expect, and should receive, pay. Second, training and maintenance. In addition to the prescribed reading, examinations of a kind, as well as routine details, will be necessary to eliminate the unfit. Third, question of rank and command. The law should provide carefully and detail exactly what duties the various classes of technical reserve officers should perform in time of war, what their pay and position should be, and should carefully distinguish between those who go with the troops and become officers in command, and those who act purely and simply as technical men and take charge, perhaps, of civilian labor performing a specified engineering or technical task. Fourth, maintenance of interest and enthusiasm. This is a matter on which it is difficult to speak in advance, but the author's suggestion in this respect, especially as regards advisory boards, seems well thought out.

With regard to the enlisted technical men for certain kinds of work, these can be obtained sufficiently well trained almost at the start, but for other kinds of work, preliminary training is absolutely essential. I am inclined to believe that technical troops can be established in the national guard and trained so that a large portion of them in time of war would be available for transfer or

incorporation in the Regular Army so as to add to the number available; if practicable, means can be found to enforce such transfer.

On the whole, the scheme of the author makes a very favorable impression, and he certainly deserves the thanks of the Army for the interest he has taken in it and the efforts he is making to improve its condition and insure its success in time of war. It is believed that he should be met with the hearty cooperation of all Army officers, and more especially by the technical branches, as understood by him.

Mr. Alex Dow

Member A.S.C.E.; A.S.M.E.; A.I.E.E.

I see little occasion for comment on Mr. Haskins' preamble, neither on his two assertions, to-wit: That we need cooperation between engineers in civil life and the Army; and that we need a technical reserve for the Army. His assertions are only items of a much larger sum, part of which is that we need a reserve for every branch of the Army; and the whole of which is that we sorely need mutual comprehension and mutual appreciation between the Army and civil life.

Now, as to the suggestion that there should be a powerful national general committee of engineers—this suggestion is good enough to act upon at once. It will be impossible, in the beginning, to assign to this committee duties as extensive as outlined by Mr. Haskins. But there is immediate work for a committee on military engineering in each of the national engineering societies; and the conjunction of these committees with an adequate committee of military engineers is a logical sequence and should in time develop into Mr. Haskins' ideal. The proper line of action towards the desired end appears to me to be a proposal, within each national society, for the appointment of such a standing committee. The committee organization and rule of practice already exists in each of the societies, and the final conjunction of all the committees is not without good precedent.

Now as to the other proposal—to provide a well-defined peacetime force of technical emergency officers. Mr. Haskins is, in my opinion, justified in dismissing his first alternative—to-wit: the provision of a vastly disproportionate number of regular technical officers attached to the permanent establishment. That the permanent establishment of technical officers should be increased beyond its present limit is painfully obvious. But that it could be increased to the limits required by a big war is just as obviously impossible. The second alternative is equally unacceptable. The national guardsman is essentially a line soldier, and the best use to which we can put the national guard organization—the result, in truth, which we should demand from it, and insist upon getting

—is the training of an adequate number of men to shoot straight with the rifle and to take proper care of themselves on march and in camp.

The third alternative, namely the selection, during peace, of a sufficient number of engineers in civil life, who, in consideration of a nominal retaining fee and a certain amount of social and professional distinction, will, during peace familiarize themselves with army engineering methods and facilities; and in case of war will be volunteers for active service as engineer officers—this alternative seems sufficiently practical to be worth trying.

My first thought about it is that Mr. Haskins is optimistic in expecting that men of high standing and reasonable mature years will, in the first instance, offer themselves for enrollment in such a reserve. These are the men who have found their work; and who are recognized as having found their work; and this recognition has served to tie them. each to his own place of responsibility. To every such man comes the dream of the undertaking of *something undone,* that he fancies would renew for him the old joy in the newness of life—and doubtless to some such men success in military engineering is the dream that most persistently recurs. But your man of mature years and high standing finds himself bound by circumstance—like Kipling's Diego Valdez—to that work which his world expects him to do; and to most engineering veterans only the instant demand of the nation for service, under actual stress of war, would warrant the undertaking of military duty. Your older engineer is patriotic, but his patriotism will not inspire him to obligate himself *in advance* to the performance of military duty upon the call to arms. And I don't think that it should.

But after a few years there will be on the list of reserve engineers many of mature years and high standing. That is the natural sequence of the enrollment during the first years of the younger men who are *going* to make good in their profession. Once playing the military game they are likely to continue playing it. They will observe toward the military part of their work the same mental attitude that they observe toward the civil part. The man who feels that he has been and is a useful reserve engineer—that his work counts and that he is showing results—he will wish to keep on doing so. Because (after all) every engineer who makes good, works for the joy of the working. I think that we need not trouble in starting a reserve such as suggested, to obtain in the first instance the proportionate number of engineer veterans. We can safely fill the reserve with the young men, who are veterans in prospect, and let nature take its course.

Will the young men come in? Yes, I think so. I am not so old that I have forgotten my own thoughts and acts as a youngster, and even in that later period when I was supposed to have begun to make good. And I can see clearly that the right kind of young

men will establish for the engineer reserve a social and professional status that will make its badge (or its letters) much to be desired.

I see a lot of possible errors in organization and in regime; but I think I see a clear course to success and it is more than clear to me that the comprehension of military necessities and civil possibilities which will be brought about by the work of committees uniting the national engineering societies with the engineering branches of the Army, is the one thing needful to insure success.

Maj. W. P. WOOTEN

Corps of Engineers

To any one who has given the least thought to the question, the desirability of providing, in time of peace, a definite source from which technical troops and officers, particularly the latter, may be quickly drawn on the outbreak of war, is self evident. The plan presented in this paper, in its final analysis, contemplates simply the preparation of a list of men qualified and willing to perform the duties of the various grades, and the appointment, from this list, of officers for the active army when the necessity therefor shall arise.

A plan, substantially the same as the one presented, has already been adopted by the War Department. Any man in the United States may have his name placed on the eligible list for appointment to any grade of any branch of the Army, technical or otherwise, by passing the examination necessary to determine his qualifications for the position to which he aspires. In case it becomes necessary to raise a volunteer army it is expected that officers for it will be selected, as far as possible, from the list of eligibles. As subsequent examinations are given, if the candidate desires to renew his certificate of eligibility upon its expiration, or if he desires to be classified as eligible for appointment to a higher grade than the one for which he is already listed as eligible, he is compelled to do enough reading to keep himself conversant with the duties which he may be called upon to perform.

Practically, then, there are but two differences between the plan now followed by the War Department and that proposed in this paper. Under the former the successful candidate receives a certificate of eligibility, while under the latter he receives an actual commission as a reserve officer of the Regular Army. The former fails to provide for any supervision over the eligibles, while the latter provides for "just sufficient general supervision to preserve them as an efficient emergency reserve." The first-mentioned difference is mainly a sentimental one, but it is not on that account the less important. An actual commission as a reserve officer would undoubtedly be more highly prized by its recipient than a mere provisional promise of a commission. The individual's interest and sense of responsibility, and therefore his efficiency, would, consequently, probably be greater. With respect to the second

difference, there is, of course, no question as to the desirability of exercising a certain amount of supervision over the eligibles or reserve officers. Just what the nature of this supervision should be, and just how far it would be practicable to extend it, are matters of detail which would require considerable thought to determine in the beginning, and which in the end would have to be greatly modified by experience.

On the whole, it would seem that although the plan proposed is perhaps better than the one now followed, the difference is not so great but that the probable results of the former may be judged by the actual results of the latter. The War Department plan has now been in operation for several years, long enough, doubtless, to afford some evidence as to its eventual success, but, so far, I have seen no statement as to whether the results of its trial are considered as demonstrating its effectiveness or not.

It seems to me that the possibility of organizing efficient technical troops as a part of the national guard is passed over a little too lightly. It may be true that the present organizations of technical troops in the national guard leave much to be desired, but, whether it is true or not, it by no means follows that a system can not be devised under which efficient organizations of this kind may be obtained. The proper presentation of such a plan would, however, require too much space to be attempted here, nor would such a plan, even if successful, entirely meet the requirements of the case, since a great number of officers of technical training would still have to be secured after the national guard had been wholly called into service.

MR. PERCY H. THOMAS

Consulting Electrical Engineer

In considering Mr. Haskins' address one is impressed with the great number of possible plans which might be followed to obtain a technical reserve, but which undoubtedly would nearly all fail to produce the desired results.

What would appear to be the most satisfactory solution, from the point of view of the Army, would be the securing of a sufficiently numerous number of actual reserve engineers, entirely familiar with the Army's organization, discipline, and with the methods and apparatus used in the various engineering services the Army is called upon to do. In the absence of an adequate number of such men, however, much benefit might be obtained from a less immediately available and more broadly founded reserve.

Before entering upon his analysis of the reserve phase of the question, Mr. Haskins has made an appeal for closer cooperation between the Army engineers and the civil life engineers. Could not a great deal be acomplished in this direction by the membership of engineer officers in the various professional technical so-

cieties, and by the active participation in the way of the presenting of papers and discussions in the proceedings of these societies, so that the questions confronting the Army engineers may become familiar to the membership in general? It is even possible that in such a society as the American Institute of Electrical Engineers, having an organization in which certain sub-committees are appointed to represent various phases of electrical activity, such a sub-committee on army and navy affairs might be appointed. Probably, further, lectures by Army engineers before technical colleges would be very welcome, and would help to attract attention to and forward the interest in military engineering affairs on the part of the undergraduates.

Considering the subject of providing available recruits for the Engineer Corps from a broader point of view, would not the following plan have desirable characteristics? Let the Government or the Army, as may be best, establish at suitable points a number of technical schools whose avowed object should be the education and training of civilian engineers, in competition with the present technical institutions. It is assumed that at the same time a certain amount of special military instruction would be given, and very likely it would be of advantage for the final year's training to consist of practical observation and participation in Government engineering work at the various army posts or stations, as far as practicable, where such work might be in progress. A suitable degree could be offered for satisfactory completion of such a course and, presumably, a reasonable tuition fee required.

From the point of view of the Government, advantage would thus accrue from the existence of a large number of engineers having an elementary training in military affairs, with some knowledge of its problems and organization, and from a working touch on the part of the Government officials with a large number of persons forming approximately the best sort of semi-trained material.

The success of such a plan would, of course, depend upon the preference of a considerable number of young men for such a Government training for their professional work over the present technical schools. I am inclined to think that these schools would be found very attractive. In the first place, because considerable prestige comes with training under the Government, and, secondly, because of the now firmly and widely recognized advantages of the semi-military discipline and physical and moral training such as could be readily obtained. No such standard as is maintained at West Point or the Naval Academy at Annapolis could, of course, be expected, nor would this be necessary. Furthermore, in my opinion, graduates of such Government schools would be preferred to graduates of most of our present technical schools by manufacturing companies and others who absorb the great majority of our technical graduates, on account of the thoroughness of training

in fundamentals, the self-reliance and breadth of view that would be expected in such men.

Presumably, a great premium would be placed by the Army on the younger men, who have more enthusiasm and patriotism, as well as more physical vigor; these are obviously the ones that would be secured by such a Government school system.

There would thus be obtained in a manner perhaps more suitable to American institutions some of the benefit obtained by European nations from the limited period of army service exacted by the government from all men.

Possibly, this plan would not provide enough men having a practical working knowledge of mechanics, etc., as distinguished from a theoretical book knowledge thereof; in which case, possibly, an institution more of the nature of a trade school might be preferable.

Of course, no such set of men as would be turned out by such institutions would wholly take the place of a progressive reserve already enlisted and constantly kept familiar with the progress of the military art.

From another point of view the scheme of Government training schools here very briefly and imperfectly outlined, is much broader and more fundamental than the providing for a technical reserve; it might be considered as a part of the country's general educational system. The necessity for the effective technical training of a larger portion of our workers is well recognized, and the results of Germany's advanced methods of education are conspicuous. While we always need the privately controlled and managed technical institutions, these have, with a few exceptions, great limitations in their small size, insufficient facilites, and inability to pay a teaching staff of the best grade. Government schools would have a great advantage in these directions and would probably be prevented from becoming too conservative by the necessity for active competition with the private institutions. While it may truly be said that many sorts of enterprises are more satisfactorily carried out in private hands than by Government control, this principle has little or no weight in educational matters.

There are, doubtless, many objections that can be urged against Government technical schools for civilian engineers, but perhaps a free discussion might show ways of avoiding them, and the idea surely has a number of features which strongly recommend it.

ROCK DREDGING AT CARR SHOAL, OCONEE RIVER, GEORGIA

BY

MR. H. L. ROBERTS

Carr Shoal, Oconee River, Ga., was in the past the most difficult and dangerous place to navigate on the system of rivers. It was not navigable at all on less than a 1 foot stage of river, and then only for very light-draft boats equipped with windlasses.

When work was first started at Carr Shoal the *Katie C*, a stern-wheel steamer of 100-foot length, 20-foot beam, and drawing 16 inches of water, came up to the shoal, bound up the river for a load of freight. As we had our breast and quarter lines across the old cut we were compelled to discontinue work until she passed and, to save time, decided to pull her through with our steam. We parted all her lines, one after the other, and finally got her through on our ⅝-inch steel wire rope. This last line had about all the strain on it that it would stand while she was passing the worst places. She was, of course, working her engines full speed ahead all the time. It took three hours to get her through the old cut and we saved an hour or two by helping her. Stage of river, 1.1 foot. This same boat has since passed up through the new cut through the dredged channel in two and three-fourth minutes. Stage of river, 0.5 foot.

The *Sapelo* started work on the new cut on the 9th day of August and finished on the 14th day of December, being four months and six days on the job.

The only serious difficulty encountered was due to lack of sufficient depth of water to float the pile driver used for drilling over the rock that was to be blasted. On account of this, it was necessary to do a great deal of preliminary work blasting by hand and, in some instances, the steam drill was carried out on the rocks ahead of the plant and a line of steam pipe and hose run to it. A considerable quantity of rock was also taken out by hand, loaded on a small barge and moved to one side. After this blasting had been done by hand, the *Sapelo* would clean off ahead of her as far as the bucket would reach (about 20 feet) and would then haul back and the pile driver would get in position and blast to depth. This in turn was dredged to depth and the operation

repeated. It is estimated that this preliminary work occupied about one-third of the working time. It was not feasible to blast very far ahead of the digging, as the material would settle back and make dredging very difficult.

The figures at the end show the amount of work done and the cost. Fig. 2 shows the position of the new cut where spoil was placed; soundings and velocity of current taken after completion.

A description of the plant and methods employed may be of interest. The *Sapelo,* built at Hollingsworth Ferry in 1903, is 85 feet long, 30-foot beam, and draws 30 inches of water. She has a ''stiff-leg'' derrick, using a Lidgerwood No. 4 swinging gear and bull wheel. The boom is 56 feet long and the bucket swings in a circle, the diameter of which is 75 feet. The bucket is a four-blade Haywood orange-peel, of 21 cubic feet capacity. The machinery will stand a speed of 75 swings an hour on a continuous run. This speed can not be attained, however, unless the rock is very well broken up. Much better time can be made on material such as sand or soft clay.

The swinging engine is a Lidgerwood Standard, double-friction drum engine, of 30 horsepower, and is in good condition. The after engine, used for stern and quarter lines, is a Lidgerwood reversible, double friction, drum engine, which has been in use a long time, but is in serviceable condition. Steam is furnished by an upright tubular boiler of ample capacity.

Drilling was done by two methods. On anything but the very hardest rock, the drills used consisted of a length of octagon steel working in a casing of 1½-inch pipe. The drill in general use was of 1⅛-inch steel with a 4-inch taper point. This was slipped inside the 1½-inch pipe used as a casing, the lower end of the pipe being drawn down to 1⅜ inches to fit snugly around the drill and then sharpened to a cutting edge. The upper end of the drill had an iron collar 1 inch thick by 4 inches square around it, the collar being held in place by upsetting above and below it. The drill extended about ½ inch above the collar. The drill and casing were driven together through rock to the required depth by an 1800-pound hammer working in the leads of the pile driver. A platform hanging from the leads in front provided a place for the men to stand while drilling and loading. Having been driven, the drill was taken out, leaving the casing in the rock. Dynamite was then loaded into the casing, a ramrod held on top of it and the casing was pulled up with the pile fall leading to the top drum of the engine, leaving the powder in the hole. These holes

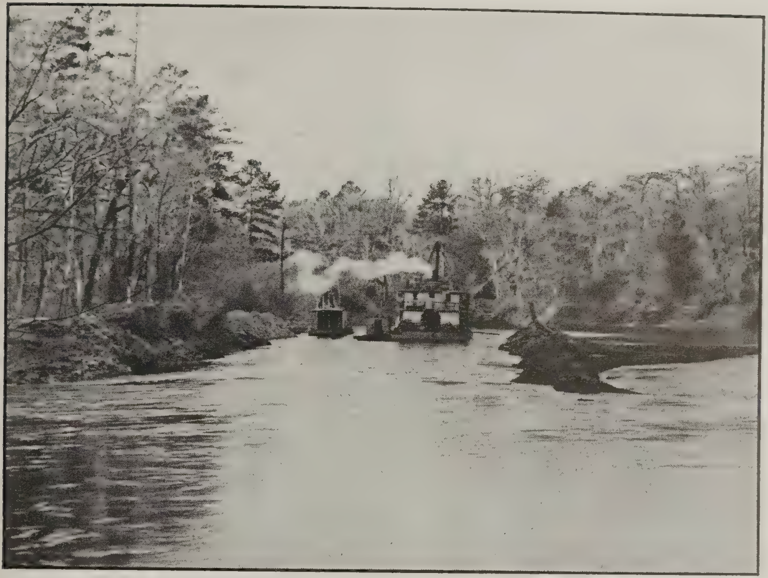

Fig. 1. Carr Shoal, Nov. 29, 1910, from upper end of cut, showing plant

were usually spaced 5 by 5 feet, and were drilled to a little greater depth than the contemplated dredging. About thirty holes were usually fired in one blast by an electric blasting machine.

It often occurred that there was a hard layer of rock on top of

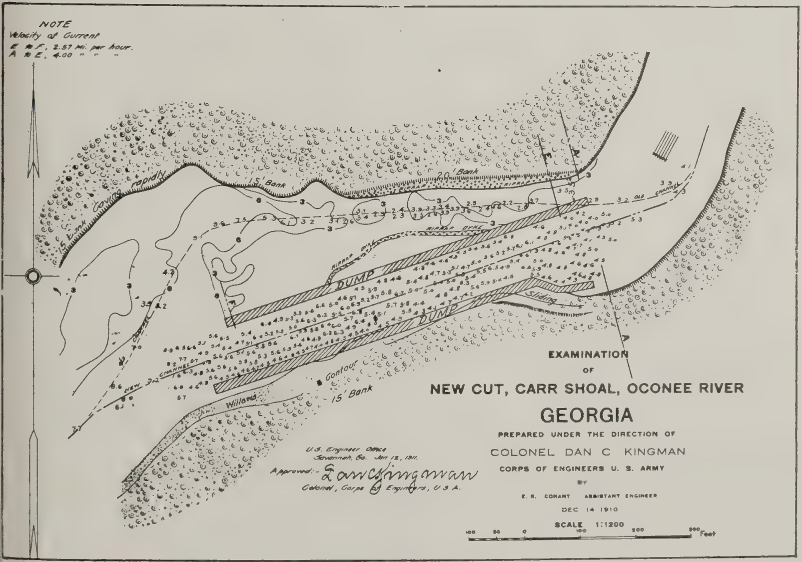

Fig. 2

soft rock. A short drill of 2-inch octagon steel was driven through this hard rock, pulled up, and the 1⅛-inch drill and casing sent down. Where it was possible to use these drills, which was about 90 per cent of the time, work could be carried forward about ten times as fast as with the steam drill.

The steam drill, the second method in use, was an Ingersoll-Rand; drilling a hole from 1¼ to 2½ inches in diameter, and when the rock was covered with live sand, as was usually the case, it was a very troublesome and slow method. The steam drill platform was mounted on the stem of the pile driver and the drilling was done through a casing of 6-inch pipe resting on the bottom. The hole was kept clear of sand by a jet of water from a horizontal, double-acting force pump, driven by a rod from the connecting rod of the pile-driver engine to the lever operating the plunger of the pump. When drilling by steam, as the last drill is pulled out, a casing is slipped into the hole to keep out the sand, and the powder loaded through this.

The average size of the crew carried was ten men—foreman, two engineers, cook, cabin boy, and five laborers; the number of laborers employed was increased or diminished as the nature of the work being done required.

Summary of Work and Cost of Same

Dimensions of cut: Length, 810 feet; width, 80 feet; depth, least, 4 feet; depth, average, 5 feet.

Dredging—Yardage Removed: Rock, 5,146 cubic yards; clay, 2,292 cubic yards; sand and gravel, 130 cubic yards.

Blasting: Number of holes drilled, 1,642; number of blasts, 139; pounds dynamite exploded, 589.

Time employed: Days actual work, 99; days delayed on account of high water, 5; day delayed other causes, ½; holidays, Saturdays, and half-holidays, 5½; Sundays, 18. Total days, 128.

Cost

Wages	$2,127.13
Subsistence	640.69
Fuel and oil	276.55
Dynamite, caps, etc.	850.37
Maintenance of plant	494.64
Drayage of supplies	47.50
Total	$4,436.88
Estimated cost of removing 2,322 cubic yards of clay, sand, and gravel from an area of 64,800 square feet, at 15 cents per cubic yard	$348.30
Cost of rock excavation, 5,146 cubic yards	4,088.58
Cost of rock excavation per cubic yard	.794
Cost of all excavation per cubic yard	.59

Book Reviews

FORTIFICATION DE CAMPAGNE, PREMIERE PARTIE—TECHNIQUE. Translated from the Russian by Captains Wehrlin and Virlet of the French Engineers. Paris, Libraire Militaire, R. Chapelot et Cie., 1910.

This is a French translation of that part of the official Russian regulations for the special instruction of engineer troops, dealing with the technical features of field fortifications.

The vast and varied experience of the Russian troops in the subject of field fortification afforded by the recent campaign in Manchuria lends a special interest to Russian ideas and in rendering these ideas generally available through the medium of the French language the translators have conferred a distinct benefit upon the military profession.

The first impression, after a perusal of the little volume, is apt to prove disappointing. Instead of any marked and radical changes in the trace, profile, and details of field works, as might possibly be looked for as a result ot the extended experiences of the Russians, we are confronted with essentially the same old familiar types represented in the latest standard works in English, French, and German. And this is no cause for wonder, for reflection should show that limitations of time, tools, and materials impose a practical limit to the technical features of field works and that this limit was essentially reached before the Russo-Japanese war. The vital lessons of this war, as regards field fortifications, are the applications of field works, especially in relation to tactics, rather than their technical features, but this aspect of the subject is not touched in the work under consideration.

Although the technical features of field works, as treated in the new Russian regulations, present no startling innovations, a careful study of the text reveals a number of minor matters of considerable importance which are, no doubt, based on the actual experience of war. Among the more important of these are the provisions for a more extended use of overhead cover and the necessity for the greatest pains to secure concealment.

Chapter I is devoted to a consideration of the profile and trace of rifle trenches, together with all accessories, such as loopholes, covers, communications, observation stations, etc. Little importance is attached to an elbow rest, in which the Russian view is at variance with other authorities.

In tracing rifle trenches, the occupation of military crests and forward slopes is recommended as being still the best place, in spite of certain recognized disadvantages. Rifle trenches are to be built for units not larger than a company, allowing two paces per man, as an average, and one pace as a minimum.

Many forms of overhead covers, or splinter proofs, are shown, and many of these were actually employed in Manchuria. This feature of rifle trenches is both valuable and instructive.

Trench work is executed by two reliefs working alternately for half an hour, which is also the Japanese plan.

Emplacements for machine guns in rifle trenches are treated at length, designs being shown for open and blinded emplacements for the different styles of mounts employed in the Russian service, which appear to include a wheeled, a tripod, and a cradle mount.

Chapter II is devoted to a consideration of artillery positions and the construction of emplacements for all types of Russian field artillery, including howitzers and mortars. This subject is treated quite exhaustively and forms one of the most valuable chapters of the book.

Chapter III treats of closed field works and is rather disappointing. The old stereotyped type of trace is still retained as a model, a lunette with two faces, two flanks and a straight gorge, although it is stated that the most favorable trace will be dictated by the ground and that it will generally be a broken or curved line forming an irregular closed figure. Four types of parapets for closed works are shown, varying from a sunken triangular profile, for hasty work, to an elevated profile having a command of about 5 feet 6 inches and a ditch 10 feet wide and 7 feet deep for more deliberate work.

While it is true that closed field works of monumental profile stood the test of the campaign in Manchuria, it is decidedly open to question whether such forms are justified, in view of the difficulty of their concealment and the great labor involved in their construction. Sunken constructions with a well-built wire entanglement would appear to offer equal advantages with far less labor.

Chapter IV is given over to a brief consideration of accessory features of closed works, such as shelters for men, dressing stations, telephone stations, store rooms, latrines, and drainage features, with type forms of each.

Chapter V is devoted to the defensive preparations of accidental features of the terrain, such as cuts, embankments, houses, villages, walls, etc., and differs in no way from the usual treatment of these matters in standard works.

Chapter VI deals with the subject of obstacles, giving extended descriptions of wire entanglements and mines. Deep military pits are still retained as an obstacle in spite of their small value in the Russo-Japanese war. This is apparently justified by the fact that pits may be constructed when materials are lacking for other and more effective obstacles.

The Russian wire entanglement offers some novelties, being in reality a combination of high and low wire entanglement, as described in ordinary text books. Stakes are planted in rows parallel to the front, 1 meter between rows and stakes 2 meters apart in the rows. Alternate rows of stakes are all low and the other rows of alternating high and low stakes. The object of varying the heights of the stakes is to prevent the ready surmounting of the entanglement by the use of hurdles, planks, etc.

Another application of wire to form an obstacle are wire cheveaux de frises. These are formed from ''saw-buck'' frames made of light spars tied together by wire in all directions. The completed frames are then disposed in front of the work acording to several schemes and wired together. These cheveaux de frises are specially applicable in stony or frozen ground where stakes can not be driven and form an effective obstacle. Such an obstacle was used by the Russians at Ling-sheng-pu on their Sha-ho lines.

Chapter VII treats of various expedients for concealing field works. The

fact that an entire chapter is devoted to this subject is ample evidence of its importance in the Russian mind and is, no doubt, the result of some bitter lessons taught by the Manchurian campaign.

Concealment is best obtained by a skillful adaptation of works to the ground. Some of the points to be observed in broken ground are the following:

1. Avoid sky lines.
2. Use low parapets.
3. Decrease width of trenches on forward slopes.
4. On forward slopes, conceal reverse slope of trench by raising parapet or revetting the exposed portion of this reverse slope.
5. Cover all trenches and communications on forward slopes with materials harmonizing with the surroundings to prevent their being seen into from the front.
6. Slope traverses to the rear.

In all ground. avoid sharp lines and angles; remove all prominent marks which will assist the enemy in ranging his artillery.

Freshly turned earth is concealed by a cover of turf or vegetation; in cultivated ground the furrows and ridges should be restored; avoid treading paths or bare spots while executing earthworks.

Concealment may also be effected by the use of screens, natural or artificial, formed of trees, bushes, crops, etc.

The Russian regulations regard concealment as an essential feature of field works and prescribe that in time calculation for the execution of works an allowance be made for measures to secure concealment.

The book closes with extended tables giving allowance of tools for the different arms of the service, calculations of time for executing various classes of field works and for fabricating revetments.

It is noticed that the Russian infantry is shortly to be equipped with an increased allowance of intrenching tools, so that every private will carry a tool, as has recently been done in the French army, a tacit recognition of the increasing importance of field works in campaign.

The work is profusely illustrated, there being 202 figures in 250 pages of text. Some of the figures are not as clear as is to be desired, but they suffice to convey the ideas intended.

The volume contains sufficient new and original ideas regarding the technical details of field works to merit its possession by every engineer officer.

—J. E. K.

FIELD FORTIFICATIONS, NOTES ON TEXT BOOKS. Lieut. Gen. H. D. Hutchinson, C. S. I., corrected to date by Col. A. C. MacDonnell (late R. E.), 1910. Gale & Polden, Ltd., London and Aldershot.

The fact that this little work has entered upon its sixth edition is sufficient evidence of its popularity and usefulness. As stated on the title page, the book is ''specially designed and arranged for the use of officers preparing for promotion examination,'' and this object is kept clearly in view in its treatment of the various subjects, which is clean cut, concise, and free from arguments.

A comparison with several available earlier editions shows that the work has kept progress with changing thought regarding the application of field works

as a branch of the military art. The subjects of concealment of field works and of the siting of trenches with respect to the terrain, as well as the employment of field fortifications in the attack of positions, are quite in line with the latest ideas.

While professing to be merely notes on the text books, the work is quite as useful as a text book itself and in some respects more so, as all really important and useful information is presented in the most compact manner possible.

In Chapter XII is given an excellent example of the applicatory system of instruction in the fortification of a section of terrain, which is carefully worked out as regards tools, materials, and time. This chapter will be found particularly instructive to the company officer of engineers. The work closes with a series of examination questions appropriate to the several chapters.

The typography is clear and the plates more than excellent, in which respect the work is decidedly superior to many recent foreign works on field fortification.—J. E. K.

SELECTED ARTICLES OF ENGINEERING INTEREST

Compiled by Henry E. Haferkorn, Librarian, Engineer School.

In the lists of selected articles published, the publication is referred to by the number preceding its title in the following list. The following abbreviations will be used: I, for illustrated; D, for diagrams.

(1) Annales des Ponts et Chaussees.
(2) American Machinist.
(3) Canadian Engineer.
(4) Canadian Society of Engineers. Trans.
(5) Cassier's Magazine.
(6) Cement.
(7) Cement Age.
(8) Cornell Civil Engineer.
(9) Electrical Review (London).
(10) Engineer (London).
(11) Engineering (London).
(12) Engineering-Contracting.
(13) Engineering Magazine.
(14) Engineering News.
(15) Engineering Record.
(16) De Ingenieur (Hague, Holland).
(17) Journal of American Society of Mechanical Engineers.
(18) Journal of Western Society of Engineers.
(19) Journal of Franklin Institute.
(20) Journal of Royal United Service Institution (London).
(21) Proceedings, American Society of Civil Engineers.
(22) Proceedings, Engineers' Club of Philadelphia.
(23) Municipal Engineering.
(24) Municipal Journal and Engineer.
(25) Railway Age Gazette.
(26) Revue Generale des Chemins de Fer (Paris).
(27) Scientific American.
(28) Scientific American Supplement.
(29) Transactions, American Society of Civil Engineers.
(30) Professional Memoirs, Corps of Engineers.
(31) Journal of the Royal Artillery (Woolwich, England).
(32) Royal Engineers' Journal (Chatham, England).
(33) Proceedings Brooklyn Engineers' Club.
(34) Concrete.
(35) Bulletin de la Presse et de la Bibliographie militaires (Brussels).
(36) Internationale Revue ueber die gesamten Armeen und Flotten (German and French). (Dresden.)
(37) Revue d'Artillerie (Paris).
(38) Kriegstechnische Zeitschrift (Berlin).
(39) The Contractor.
(40) Cement Era.
(41) Canal Record (Ancon, C. Z.).
(42) Proceedings, Engineers' Society of Western Pennsylvania.
(43) Journal, United States Artillery.
(44) Transactions, Society of Engineers (London).
(45) Journal, Association of Engineering Societies.
(46) United States Naval Institute. Proceedings.
(47) Revue du Genie Militaire (Paris).
(48) La Technique Moderne (Paris).
(49) Electrical World.
(50) Electrical Review (Chicago).
(51) Journal, Military Service Institution,
(52) Barge Canal Bulletin.

ARMORED CARS.

Armored cars in the Mexican revolution. (27), April 22, 1911. I.

ASTRONOMY.

Astronomy for the army. (20), March, 1911. D.

AUTOMOBILES, MILITARY.

Military motor road train. (10), April 7, 1911.

BAR HARBORS.

Notes on the bar harbors at the entrances to Coos Bay and Umpqua and Siuslaw rivers, Oregon. M. L. Tower. (29), vol. 71, March, 1911. D.

BREAKWATERS.

Breakwaters on the west coast of Jutland. C. Van Langendonck. (28), April 8, 1911. I.

BULKHEADS.

A light timber bulkhead. D. C. Webb. (14), April 13, 1911. D.

CANALS.

Canals and inland navigations of Ireland. (10), May 12; June 2, 1911.—Canals in the service of coast defense. Trans. R. Van den Corput. (43), May-June, 1911.—Dredging operations in Everglades. (39), May 1, 1911. D. I.—Existing and projected canal system of the Salt River irrigation project, Arizona. (12), April 12, 1911. D.—The Granite Reef diversion dam, Arizona. (15), May 20, 1911. I.—Hydraulic dredge on canal excavation. P. J. Cleaver. (39), May 15, 1911. I.—Irrigation in the land of the Five Waters, the Punjab, India. W. G. Bligh. (14), May 18, 1911. D.—Irrigation projects of the southern Alberta Land Company. (15), May 27, 1911. D. I.—Method of canal excavation using a locomotive crane with a drag line bucket. (12), May 10, 1911. I.—The Mid-Scotland ship canal. (10), April 7, 1911.—New ship lock and locks of St. Marys river. J. C. Mills. (27), June 3, 1911. D.—Notes on three irrigation projects in the Punjab, India. A. B. Segur. (14), May 18, 1911. D. I.—Paris to Dieppe canal. (10), April 7, 1911.—Proposed drainage canal and levee work for the protection of East St. Louis from floods. (12), March 15, 1911. D.—Pumping plants on the Manchester ship canal. (10), March 24, 1911. D. I.—Remedy in waterways. F. H. Snow. (Journal of the Engineers' Soc. of Pa.), April, 1911.—Suez canal and its traffic. (15), March 25, 1911.—The Tieton Canal. E. G. Hopson. (29), vol. 71, March, 1911. D. I.—The U. S. Government and the New York State canals. Part 2. W. Symons. (52), Feb., 1911.—The Paris Harbor Project. (30), July, 1911. D.—The Brussels ship canal. (30), July, 1911. D.

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Construction of the Galveston causeway. I.,(15), May 27, 1911. I.

COAST DEFENSE.

Damp walls. A study of causes and remedies. Brig. Gen. W. A. Jones. (13), June, 1911. I.—Defence of the land front of a coast fortress, . . . H. de T. Phillips. (31), April, 1911. I.

COFFERDAMS.

Progress in raising the U. S. Battleship *Maine*. (15), May 20, 1911. D.; Progress on the cofferdam around the wreck of the *Maine*. (14), May 18, 1911. I.—Rio Guaso irrigation dam with automatic shutters. (15), May 13, 1911. D. I.

COMPRESSED AIR.

Profitable refinements in contractors' compressed-air plants. F. Richards. (14), April 20, 1911. D. I.

CONCRETE.

Cost of a reinforced concrete retaining wall. (12), March 22, 1911. D.—Damp walls. See under Coast Defense.—Demolishing a reinforced concrete building. (28), June 3, 1911. I.—Field-made rig for raising panels and concrete. (7), May, 1911. D. I.—Electrolytic corrosion of iron in concrete. C. F. Burgess. (18), May, 1911. I.—Reinforced-concrete hollow caissons floated into place in piers, Kobe Harbor works. (14), June 1, 1911. I.—Reinforced concrete tower for marine leg. (15), April 29, 1911. D. I.—Reinforced concrete trestle on the Rock Island Railroad. (15), April 29, 1911. D. I.—Reinforced concrete work in cold weather. G. C. Newton. (14), June 1, 1911. D. I.—Simple formula for calculating the strength of reinforced concrete. E. Stokes-Roberts. (32), May, 1911.—Spacing of stirrups in reinforced concrete beams. T. E. Kelsall. (34), June, 1911.—Two reinforced concrete coal pockets. M. S. Falk. (29), vol. 71, March, 1911. D. I.—Reinforced concrete crane runways. (39), March 15, 1911. I.

COST-KEEPING.

Cost-keeping systems employed on the Panama Canal. Ad. Faure. (15), March 25, 1911.

CRANEWAYS.

Reinforced concrete crane runways. (39), March 15, 1911. I.

CRANES.

Coaling crane for the Ferrocarril de Langreo, Spain. (11), March 31, 1911. I.

DAMS.

Cost data on the new Croton Dam. E. Wegmann and J. B. Goldsborough. (39), March 15, 1911. D. I.—Dams on sand foundations. Discussions. (21), April, 1911. D.—Dedication of the Roosevelt Dam. C. J. Blanchard. (27), March 18, 1911. I.—Discussion of a cellular dam design. C. J. Bancroft. (12), March 22, 1911. D.—Extension of the Sweet-water Dam. J. D. Schuyler. (14), March 30, 1911. D. I.—Failure of the Yuba River debris barrier, and the efforts made for its maintenance. H. H. Wadsworth. (29), vol. 71, March, 1911. Fold. D. I.—The Goat River Dam of the Columbus Power Co. (15), April 8, 1911. D. I.—The Granite Reef diversion dam, Arizona. (15), May 20, 1911. I.—Grouting the Olive Bridge Dam. (15), April 8, 1911. D. I.—Irrigation project of the southern Alberta Land Co. (15), May 27, 1911. D. I.—King Creek power plant construction. (39), June 1, 1911. I.—Limitations of hydraulic sluicing in building dams. (15), May 13, 1911.—The Marble Falls dam on the Colorado River. (15), May 6, 1911. D. I.—A masonry-faced earth dam having unusual features; Bishops Creek irrigation system, Nev. (12), April 12, 1911. D.—Method and cost of constructing by hydraulic sluicing the Conconully dam of the Okanogan Irrigation project, Washington. D. C. Henry. (12), May 10, 1911. D.—Methods and cost of constructing the Cold Springs earth fill dam for the Umatilla irrigation project, Oregon. D. C. Henry. (12), May 24, 1911. D.—The Morris dam at Waterbury, Conn., water-supply extension. (14), March 23, 1911. D. I.—New Hauser Lake Dam. (15), June 10, 1911. I.—A new type of dam (on Niobrara River). Editorial. (15), April 29, 1911.—Possibilities of improved navigation on the Susquehanna River. F. Gannett. (Journal of the Engineers' Soc. of Pa.) April, 1911. I.—Progress on the Ashokan Reservoir, New York water supply. (15), April 15, 1911. I.—Progress on the Barren Jack Dam. (15), May 6, 1911. I.—Progress on the Tennessee River power development. (15), June 10, 1911. I.—Repairing the earth dam of the Julesburg reservoir. (15), April 29, 1911. D. I.—Reversed dams. R. C. Beardsley. (12), March 22, 1911.—Rio Guaso irrigation dam with automatic shutters. (15), May 13, 1911. D. I.—Some recent developments in the design and construction of earthen dams. A. ff. Garrett. (34), June, 1911.—Spillway dam for the Lost River Diversion channel. (15), March 18, 1911. D.—Two earth dams of the U. S. Reclamation Service. (21), April, 1911. D. I.—Under pressure of water on dams. E. Godfrey. (12), May 3, 1911. D.—Wave action on earth dams. (12), April 26, 1911.—Willow River irrigation project. (15), May 20, 1911. D. I.

DERRICKS.

Portable gasoline derrick. (15), May 27, 1911. D.—Field-made rig for raising centering panels and concrete. (7), May, 1911. D. I.—Simple derrick with adjustable boom. (30), July, 1911. D.

DEMOLITIONS.

Demolishing a reinforced concrete building. (28), June 3, 1911. I.

DOCKS.

Covering a river's front with docks, tracks and parks. (27), May 6, 1911. I.—New fish dock at Fleetwood. (10), April 28, 1911. D. I.

DRAINAGE AREAS.

Variability of run-off of Minnesota streams during the low-water season of 1910. R. Follansbee. (14), May 4, 1911. D.

DREDGES AND DREDGING.

Dredging on contract 30, New York State barge canal. (15), June 10, 1911. I.—Dredging operations in Everglades. (39), May 1, 1911. D. I.—Hydraulic dredge on canal excavation. P. J. Cleaver. (39), May 15, 1911. I.—Some new excavating machines. (14), March 16, 1911. I.—Early dredging appliances and steam dredges. (30), July, 1911.

DRILL BOATS.

Hydraulic dredge on canal excavation. P. J. Cleaver. (39), May 15, 1911. I.

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A civilian's suggestions for a technical reserve for the Army. C. D. Haskins. (30), July, 1911.

EXCAVATION AND EXCAVATORS.

Hydraulic dredge on canal excavation. P. J Cleaver. (39), May 15, 1911. I.—Method of canal excavation using a locomotive crane with a dragline bucket. (12), May 10, 1911. I.—Some new excavating machines. (14), March 16, 1911. I.—A traction-engine excavator. (14), April 6, 1911. I.

FLOODS.

Proposed drainage canal and levee work for the protection of East St. Louis from floods. (12), March 15, 1911. D.

FORTIFICATION.

Damp walls. Brig. Gen. W. A. Jones. (13), June, 1911.

HARBORS.

Improvement of the port of Antwerp, Belgium. (15), June 10, 1911. D. Fold., plate.—Improving the port of Liverpool. (27), April 8, 1911.—Kobe harbor improvements. (10), March 24, 1911. I.—New harbor obstructions at Toulon. (43), May-June, 1911.—Notes on the bar harbors at the entrances to Coos Bay and Umpqua and Siuslaw rivers, Oregon. M. L. Tower. (29), vol. 71, March, 1911. D.—The port of Montreal. (10), April 21, 28, May 5 1911. D. I.—The port of Rangoon. (10), June 2, 1911. D. I.—Rol-en schuifdeuren in Belgie en Duitschland. A. E. Kempees en J. A. Ringers. (16), May 13, 1911. D. I.—Travelling stages for harbor work. (11), March 17, 1911. D. I.—Reinforced-concrete hollow caissons floated into place in piers, Kobe harbor works. (14), June 1, 1911. I.—Improvement of Aransas Pass, Texas. Maj. G. P. Howell. (30), July, 1911. D. I.—Discharge of unpurified sewage into the Hudson River near Yonkers. Col. W. M. Black. (30), July, 1911. D.—The Paris harbor project. (30), July, 1911. D.—The Brussels ship canal. (30), July, 1911. D.

HYDROMETRY.

Hydrometry as an aid to successful operation of an irrigation system. J. C. Stevens. (29), vol. 71, March, 1911. D.

INLAND NAVIGATION.

Canals and inland navigations of Ireland. (10), May 12, June 2, 1911.—Internal navigation in Ireland. (11), May 5, 1911.—Remedy in waterways. F. H. Snow. (Journal of the Engineers' Soc. of Pa.) April, 1911.

INSTRUMENTS.

Recent work with the precise level instrument of the U. S. Coast and Geodetic Survey. H. C. Mitchell. (14), March 23, 1911. I.

IRRIGATION.

Existing and projected canal system of the Salt River irrigation project, Arizona. (12) April 12, 1911. D.—Irrigation project of the Southern Alberta Land Co. (15), May 27, 1911. D. I.—A masonry faced earth dam having unusual features; Bishops Creek irrigation system, Nev. (12), April 12, 1911. D.—Notes on three irrigation projects in the Punjab, India. A. B. Segur. (14), May 18, 1911. D. I.—Irrigation in the land of the Five Waters, the Punjab, India. W. G. Bligh. (14), May 18,

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LEVEES.

Proposed drainage canal and levee work for the protection of East St. Louis from floods. (12), March 15, 1911. D.

LIGHT-HOUSES.

Construction du phare de la Jument d'Ouessant. C. Ribiere. (1), March-April, 1911 D. I.

LOCKS AND LOCK GATES.

Concerning the design of a 10-inch gate-valve casing. (14), May 11, 1911. I.—Erection of the Panama lock gates. (15), June 3, 1911. D. I.—Lock gate operating machines. (41), April 26, 1911. D. (50), May 20, 1911. D.—Mammoth locks of the Panama Canal. W. Bernard. (27), March 18, 1911. I.—New slip lock and locks of St. Marys River. J. C. Mills. (27), June 3, 1911. D.—Pacific locks plant. (41), Jan. 4, 1911. D.—Rol-en schuifdeuren in Belgie en Duitschland. A. E. Kempees en J. A. Ringers. (16), May 13, 1911. D. I.—The Granite Reef diversion dam, Arizona. (15), May 20, 1911. I.—Rebuilding lock gates, Milan Section of Illinois and Mississippi Canal, during seasons of 1910-1911. J. C. McElherne. (30), July, 1911. D. I.—The Brussels ship canal. (30), July, 1911. D.

MILITARY BRIDGE MATERIAL.

Timber for ponton material. J. H. Earle. (30), July, 1911. D.

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A theory of the water wave. M. F. Sanborn. (29), vol. 71, March, 1911. D.—Wave action on earth dams. (12), April 26, 1911.

Editorial Notes

The subject of riparian rights is one under which questions are continually arising in various engineer districts in connection with the relations existing between the public and the owners of the adjacent land. The question becomes one of additional importance when it arises in connection either with the Government work or public rights along a city water front.

In our last issue we published an interesting digest from an important decision by Judge Bordwell in connection with the tide lands of Los Angeles Harbor, and the following is of considerable interest along parallel lines. The following is an opinion given by the Attorney General as to whether

> * * * the existence of bulkhead or so-called ''harbor'' lines on the Hudson River from Troy to below New Baltimore precludes the Government, in the prosecution of improvements in the river at that point, from depositing the excavated material in the areas of shoal water behind and shoreward of the said lines without the consent of the owners and without making compensation.
>
> I am of opinion that the existence of these lines does not have this effect.
>
> There can be no question that, prior to the delineation of said harbor lines, the Federal Government had the sovereign right, under its duty in respect to interstate commerce, to take material excavated from one portion of the bed of a river and deposit it in another portion of that bed (whether deep or shoal water); and this without the consent of the owner of the fee in the submerged soil and without compensation to him.
>
> *Scranton* v. *Wheeler,* 179 U. S. 141, 163-4.
> *South Carolina* v. *Georgia*, 93 U. S. 4 at p. 11 semble.
> *Barney* v. *Keokuk,* 94 U. S. 324, 337-8.
> *Gibson* v. *U. S.,* 166 U. S., 269, 271.
> *So. Pac. Co.* v. *West. Pac. Co.,* 144 F. R. 160, 192-3.
> *Hawkins Point Light House Case,* 39 F. R. 77.
> *Hill* v. *U. S.*. 39 F. R. 172.
> *22 Op. Atty. Gen.* 646.
> *Cf. 27 Op. Atty. Gen.,* 311.
>
> Also, it is clear that, prior to the delineation of the said harbor lines, there coexisted beside, but subject to, these rights and powers of the Federal Government, a subordinate right in the owner of the

submerged soil to build bulkheads and wharves, and to fill in, up to the point at which actual navigation would be obstructed.

> *Yates* v. *Milwaukee,* 10 Wall. 497.
> *Ill. Cent. R. Co.* v. *Ill.* 146 U. S. 387, and below 33 F. R. 755 (Harlan, J.).
> *St. Paul R. Co.* v. *Schurmeir,* 7 Wall. 272.
> *Dutton* v. *Strong,* 1 Black 23.

The question then is, what effect, if any, did the delineation of these harbor lines have upon these coexisting rights of the Government on the one hand and of the owner of the submerged soil on the other.

To determine that question it is necessary first of all to examine the Act of Congress by which the lines were authorized (Act Aug. 11, 1888, Sec. 12; 25 St. L. 400), and which is in fact the only express statement of their meaning and intended effect. This express statement is as follows:

> Sec. 12. Where it is made manifest to the Secretary of War that the establishment of harbor lines is essential to the preservation and protection of harbors, he may, and is hereby authorized to cause such lines to be established, beyond which no piers or wharves shall be extended or deposits made except under such regulations as may be prescribed from time to time by him.

Clearly there is here no express language either of abdication by the Government of any of its rights and duties or of grant to the private owner of any new affirmative rights. On the contrary, the language is entirely prohibitory—fixing the point beyond which piers, wharves, or deposits must not go. And in the later amended form of the section, criminal punishment is provided for violation of the prohibition. (Act Sept. 11, 1890, Sec. 12.) In short, the statutory definition of the lines, so far as its express terms go, merely announces specifically the position of the navigable channel, up to which the owner of the submerged land had, as I have stated, an already existing right to wharf or fill.

Is there, however, implied, even if not expressed, in such an announcement, a positive change of rights of the parties up to this boundary so announced? I see no valid grounds for such an implication. The line was drawn in water. The river, part deep and part shallow, remained as before, and also as before there remained the public necessities for using the shallow water and its bed in the service of navigation. Nothing actually happened except that the Government, having a certain jurisdiction over the entire river, and the owners of the submerged lands having certain rights excepting in the channel, the Government designated for the information of the owners the whereabouts of that channel. It is not apparent how such a designation implies the termination of the former status of the parties up to the channel; for certainly even the implied recognition of the pre-existing rights of the owners was not inconsistent with an intention also to continue the pre-existing rights of the public. That these two sets of rights are

not mutually exclusive is shown by their original undoubted coexistence.

While the power of dumping in the particular case to which you refer may not be itself of very high importance, the principle affecting it would necessarily also affect even the most essential uses of the stream in the public interest; and the powers and duties involved are therefore of so high a degree that they can not be deemed to have been abdicated without the most explicit language or the most unavoidable implication. Indeed, it is doubtful if they can be abdicated at all. *Illinois Central R. R. Co.* v. *Illinois,* 146 U. S. 387.

Of course, the question might be different if the private owner had actually filled in, thereby physically removing his land from the body of the river and making it a part of the upland. But here we have no such change; the water remains, and the soil beneath is still a part of the bed of a navigable stream.

Under such circumstances I am clearly of the opinion that so long as these physical conditions exist, the Government's rights and duties, which arose from them, continue to exist.

I am confirmed in these views by a considerable body of precedent, from which I have found no dissent.

The opinion of Attorney General Griggs that harbor lines once established could be changed (22 Op. A. G. 501) is, it seems to me, in effect an answer to your present question, because, if the delineation of harbor lines is construed to be an abdication by the Government of its governmental rights, and a corresponding acquisition by the private owner of exclusive rights, the owner could no more properly be deprived of this acquisition by a change of the line than by Government action outside the line. I see no legal reason, for instance, in the present case, for supposing that the Government could acquire the right to dump in the shoal waters of the river by going through the form of a purely ex-parte revocation of the bulkhead line when it could not have that right without going through that form.

In *Turner* v. *People's Ferry Co.,* 21 F. R. 90 (Circuit Court, Southern District of New York), Judge Brown carefully considered the point and reached the conclusion (pp. 94, 102, 103) that the establishment of a harbor line did not give an exclusive right to the owner of the land under water, but that the public right in the interest of navigation continued, at least until the private owner had himself filled in and reclaimed the land under water, and whether it continued even after that Judge Brown found it unnecessary to consider.

In *So. Pac. Co.* v. *Western Pac. Co.* v. the *American Dredging Co.*, 144 F. R., 160, an injunction was sought among other things to restrain the Dredging Company (which was acting in the improvement of a river under the authority of the Government) from dumping the dredged material into shoal water lying between the harbor line and the shore. The court held (p. 203) citing 22 Op. Atty. Gen., p. 646, *supra,* that this injunction should not be granted, as the power of Congress to improve the harbors and

navigable waters "carries with it the right to deposit the material removed in making the improvements in any other part of the harbor or navigable waters or other place within its control." The court did not enter into a particular discussion of the specific question whether the establishment of the harbor lines affected this right, but the question was involved in the facts of the case.

In the *Hawkins Point Light House Case* (*Chappell* v. *Waterworth*) 39 F. R. 77, it was similarly held that the Government had the power to build a light house in shoal water without compensation to the owner of the submerged soil. Here again, in fact, lines had been established, but neither counsel nor the court appear to have supposed that that would affect the question.

The state courts have uniformly held that the establishment by states and municipalities of harbor lines similar to those established in this case by the Federal Government, does not oust the sovereign (in these cases, the state), at least until the land has been actually reclaimed. This view is held not only in those cases where the establishment of the lines is construed to be a mere revocable license,

Rhode Island Motor Co. v. *City* (*R. I.*) 55 Atl. 696.
Stevens v. *Paterson, etc., R. Co.*, 34 N. J. L. 532.
Turner v. *City of Mobile*, 135 Ala. 73, 129.
Eisenbach v. *Hatfield*, 2 Wash. St. 236.
People v. *Williams*, 64 Cal. 498.
Lane v. *Board of Harbor Commrs.*, 70 Conn. 685.

but also in those cases in which the lines are deemed to recognize a transferrable property right.

Boston & Hingham Co. v. *Munson*, 117 Mass. 34.
Miller v. *Mendenhall*, 43 Minn. 95, 101.
Hanford v. *St. Paul & Duluth R. Co.*, 43 Minn. 104.
Bradshaw v. *Duluth Imp. Mill Co.*, 52 Minn. 59, p. 65.
Rumsey v. *N. Y. & N. E. R. R. Co.*, 133 N. Y. 79, 89.

I have not lost sight of the fact that in these cases the actual title to the soil under water was in the state itself, but the decisions do not rest upon that fact so much as upon the sovereign control of the state over navigation, and I do not think they are validly to be distinguished from the situation which your question presents.

Incidentally, it is difficult to imagine how the dumping of soil in the shoal waters in question could be of any actual injury to the owners whose own rights are substantially limited to such reclamation. *So. Pac. Co.* v. *West Pac. Co., supra.*

I am of opinion, therefore, as above stated, that the shoal waters of a river may still be made to serve the purposes of navigation notwithstanding the delineation of the harbor lines.

The following is an extract from a speech by Attorney Frank C. Smith in connection with the public water rights of East St. Louis, and the decisions quoted bear very directly upon the public rights of the city's water front.

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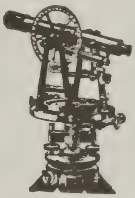

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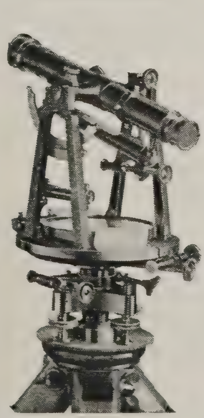

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In the case of *City of Newport* v. *Taylor,* 16 B. Mon. 699, decided by the Kentucky Supreme Court, where it was sought to reserve the space between the street and river, the court held, "That there could be no such exclusive ownership; that the only right reserved was to land a ferry at a particular place; that the space between the street and the river was for the public use. In that case the lots and streets extended only to the 'Esplande.' The Esplande extending up and down the river front. On page 704 the court said, 'The location of a town on a navigable river is for the benefit of the public to use the river as a highway and any space between the street and the water's edge is presumably dedicated to the public. And in the case of *Rowan* v. *Portland* (Ky.) 8 B. Mon. 237. A party by the name of Lyttle laid off a town on the Ohio River and sought to reserve the space between the street and the water 'for a private purpose.' The court said, however, that the space between the street and the river was for the use of the public. Any private rights thereto was forfeited to the public. In the case of *Potomac Steam Boat Co.* v. *Upper Steam Boat Co.*, 109 U. S., p. 672, wherein the right of the river front of our nation's capital was involved, the lot owner fronting on Water Street insisted that he had not relinquished his rights opposite his lot, between Water Street and the river. The court said, 'In laying out Water Street on the banks of the Potomac River the presumption is that it was for public purposes, for the erection of wharfs, landings, etc., and to give access to the river for persons desiring to use the same. It would be an outrage to think that a private monopoly could claim the river front in a city like Washington. Water Street belongs to the city and the accretions between Water Street and the river belong to the city.' (In this case the United States Supreme Court approved the holding in the Kentucky case, wherein it was held that any private right between the street and the river was forfeited to the public.)

"In 103 Wis., 271, the court of that state held that 'There could be no zone of private ownership between the street and the river; that such space was for the benefit of the public to give access to and from the river.' "

In a case where the city of St. Paul was involved (*R. R. Co.* v. *Schurmeier,* 7 Wall 272), wherein the owner of a tract of land fronting on a street up and down the river contended that he owned to the middle of the stream. It was held "that the Mississippi River was a navigable stream in the same sense as it applied to the Great Lakes and that the dedication of a public street on the river front gave to the city the riparian ownership to the water's edge or middle of the river, and that the accretions between such street and the river belong to the city."

In another case wherein the city of Demopolis, Ala., was an interested party (*Webb* v. *Demopolis Sup. Ct.* Ala., 1892). The parties had been in possession of the river front since 1884. There was a fence along the river, the highway if one had ever been there, had not been used since '44. The court said, however, that there was a highway along the river and the fact that it was not used

as a street made no difference; that the statute of limitations did not run against the public; nor could the public be barred from the river by a reservation in the plat such as ''This space reserved for an esplanade.''

In that case the court said ''It would be as presumptuous to contend that there could be *private ownership of the water itself as of the space between the street and the river.''*

The city of Cleveland is now engaged in litigation with reference to its lake front. In 1845 the city council of Cleveland for $15,000 (railroad stock) apparently sold Bath Street—a street parallel with the lake—to a railroad; during the succeeding years the lake receded, and upon the accretions formed miles of railroad tracks were built. The court decided that the so-called sale of Bath Street was fraudulent and void and that Bath Street belonged to the city, but Mr. Railroad attorney said, ''We have paid taxes since 1845.'' The court replied, ''The statute does not run against the public.'' But we certainly own the space, accretions (30 acres) between the street and the lake, we have had possession and paid taxes thereon since 1845, but the court said, ''No; the street belonging to the city, the accretions are a part of the street, hence the space between the street and the lake belong to the city.''

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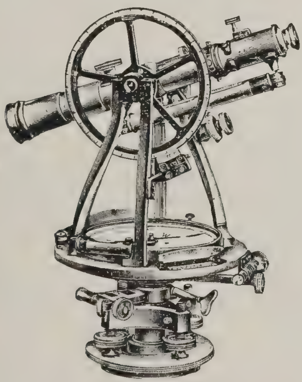

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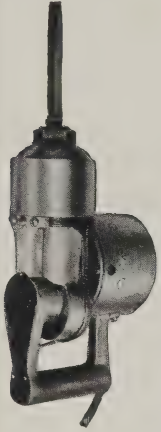

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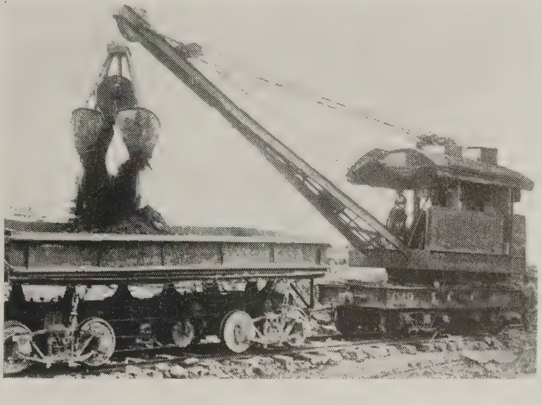

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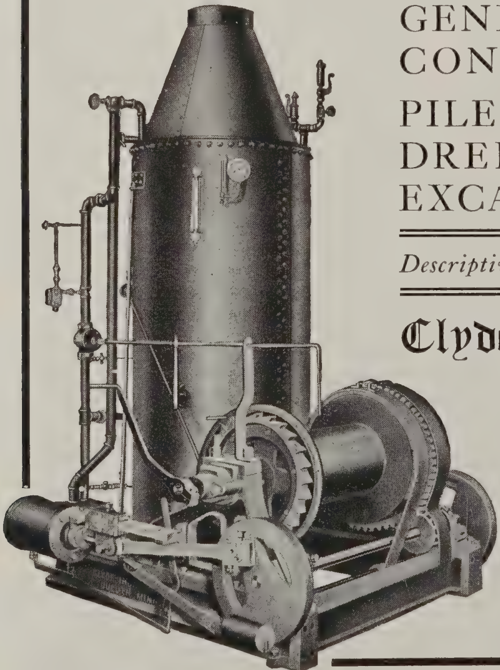

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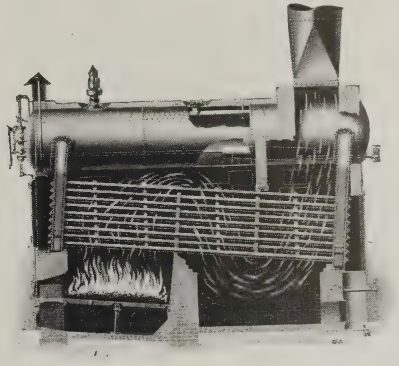

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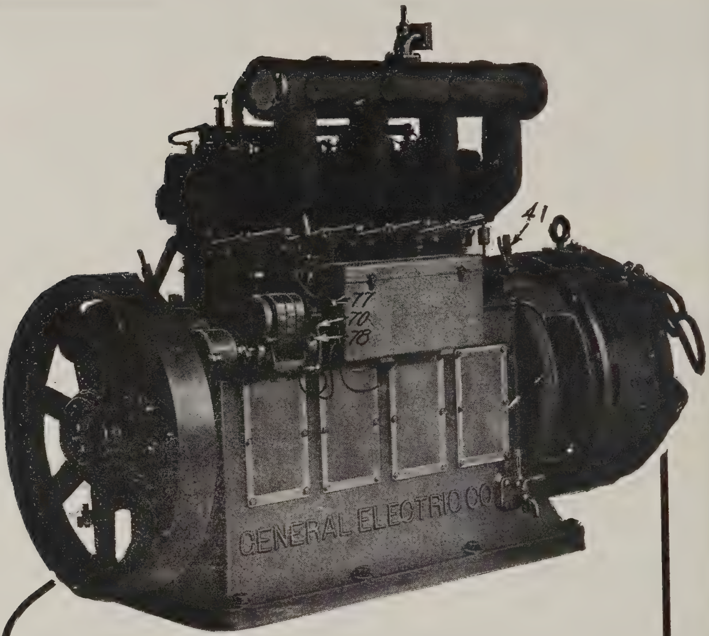

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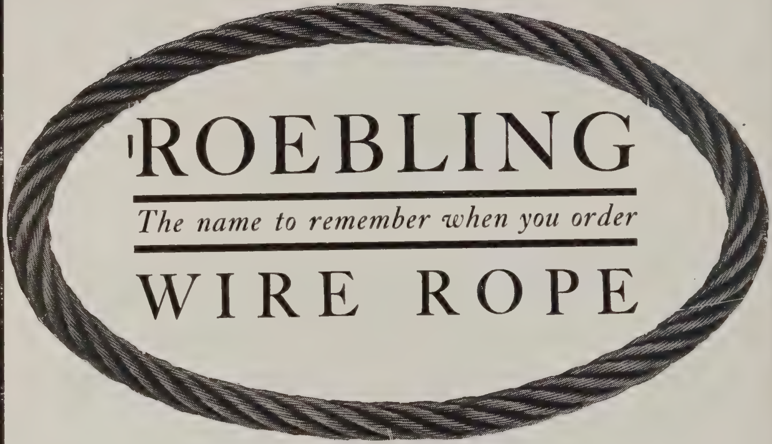

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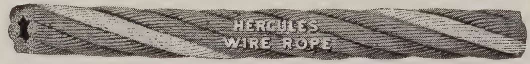

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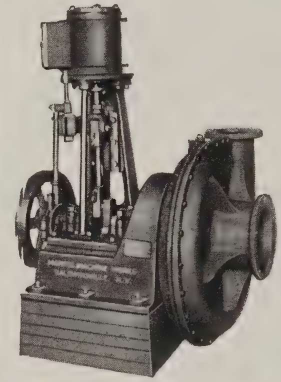

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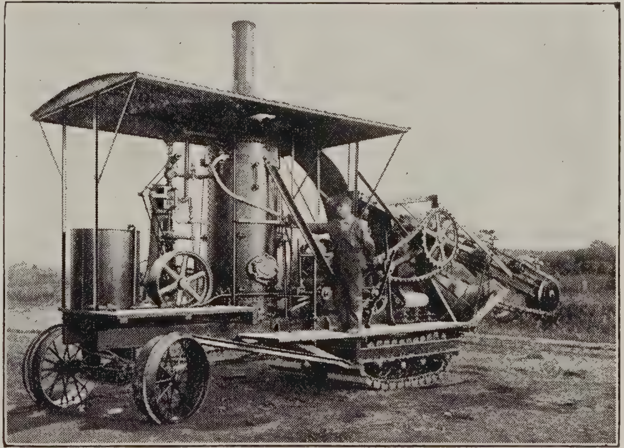

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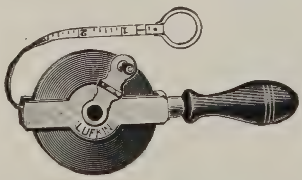

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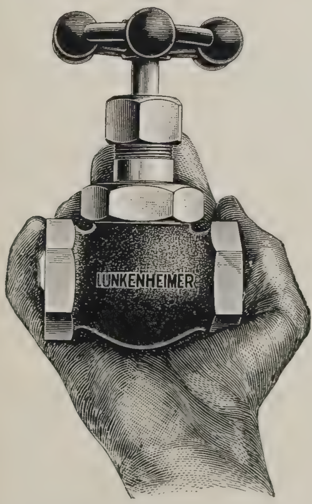

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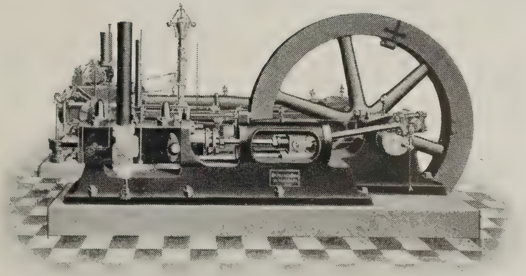

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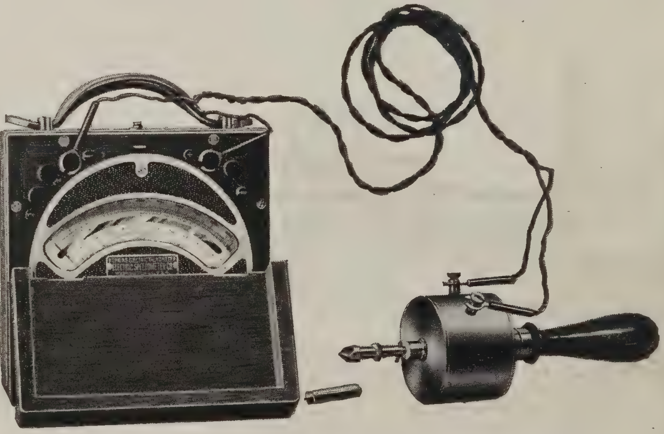

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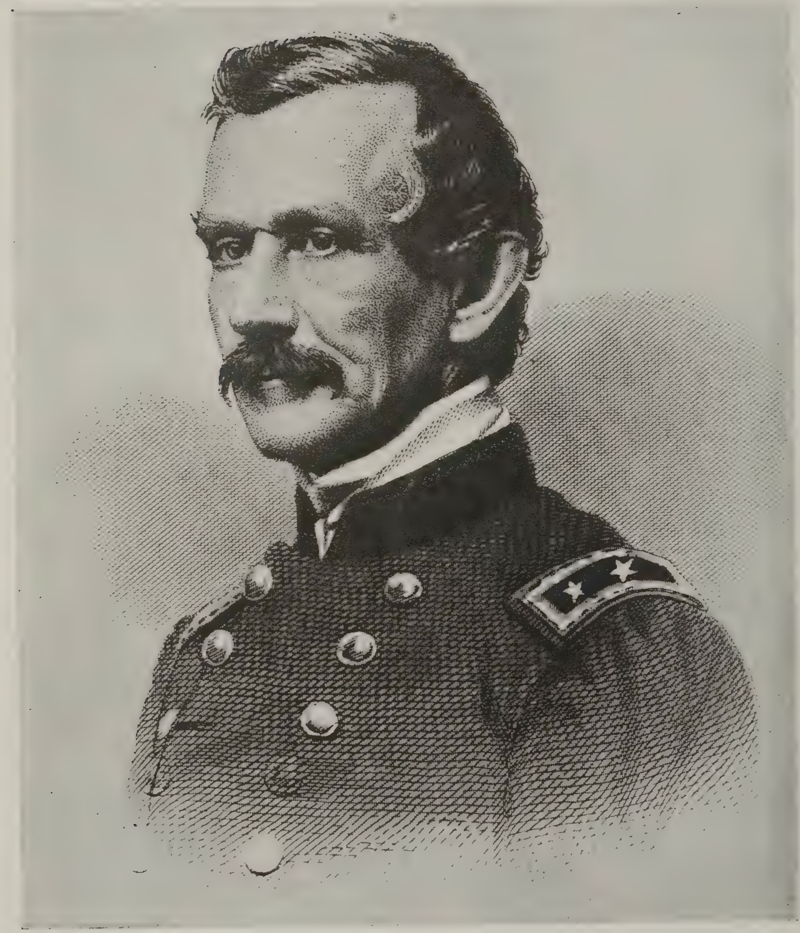

Brig. Gen. Andrew Atkinson Humphreys
CHIEF OF ENGINEERS, UNITED STATES ARMY
1866-1879
BORN 1810—DIED 1883

LOCKS AND MOVABLE DAMS OF THE OHIO RIVER

BY

Mr. J. W. ARRAS
Assistant Engineer

MAINTENANCE AND OPERATION

The system of improvement inaugurated on the Ohio River contemplates fifty-four locks and dams between Pittsburg, Pa., and Cairo, Ill. Of these there have been constructed and placed in commission, or are practically ready for operation, numbers 1, 2, 3, 4, 5, 6, 8, 11, 13, 18, 37, and the dam at head of falls at Louisville, Ky. Except the last named, the dams are composed of Chanoine wickets in their navigable passes with pool-regulating weirs, generally of bear-trap gates or Chanoine wickets. The lengths of wickets vary between 9 feet 9 inches for the lowest weirs and 18 feet for the highest passes, and the vertical heights of bear-trap gates above upper sill from 9.2 to 15 feet. The usual width of navigable passes is 600 to 700 feet, and of bear-trap gates 91 to 94 feet with extreme limits of 52 and 120 feet. This arrangement of dam will probably be closely adhered to above Louisville, while below the falls some modifications may be found advisable because of material difference in stream conditions. The approximate lock dimensions are 110 feet width and 600 feet length between lock gates. The locks are equipped with the rolling type of gate, built of steel, and with a few exceptions are filled through sixteen cast-iron butterfly valves, 4½ feet in diameter, in river wall above dam, and emptied through the same number of similar valves in that wall below dam. Concrete masonry throughout, with timber pile support and stone-filled protection cribwork on gravel foundations, wooden wickets and iron or steel working parts constitute the principal forms of construction.

Generally the power for lock operation, involving principally the valve and gate maneuvers, is compressed air, generated by steam, gas engine or water turbine plants or a combination of two of these.

For operating dams steam is used on maneuvering boat, for repairs steam on derrick and pump boats and hand power or compressed air for operating weirs. Each lock is provided with a duplicate power plant to prevent delay to navigation in event of a machinery breakdown. The operation of lock valves is accomplished through the medium of a neutral oil delivered into the valve-jack system by means of pumps or by direct pressure from the compressor system.

The foregoing brief description of Ohio River movable dams is deemed sufficient by way of introduction to the subject under consideration, in view of the frequency of comparatively recent publications dealing comprehensively with movable dam construction. What shall follow is therefore intended to apply as far as practicable to their maintenance and operation.

It is probable that in the past too decided a distinction has been made between original construction and maintenance and operation, oftimes tending, doubtless, to the disadvantage of both. While apparently differing widely in the nature of their operations, yet in reality their relationship is so close that at any time the latter may involve almost any feature of the former and eventually must of necessity absorb practically all of it. Happily, the advisability of bringing and keeping these two departments of work in closer touch as a means to their mutual advantage is being more fully realized. As this policy is developed unsatisfactory elements in the works are eliminated and cost of both construction and operation reduced.

Failure to recognize the value of this essential doubtless caused many of the nation's railroads to suffer greatly in their original building, whereas in their reconstruction, in large part at least, which in some cases was also almost immediate, the dominant consideration has been economy of operation and maintenance. In factory, mill, and mine construction to-day only that is regarded as superior which tends to minimize the cost of operating and maintenance proportionate to the output. And so all along the line of the great commercial industries economy in cost of production is the watchword. And these questions of economy are usually determined not so much by a fine discrimination among highly developed mechanisms as by a careful selection and application of designs and agencies which experience has shown to have best withstood the test of endurance to perform their functions faithfully at the minimum cost of repair, renewal, and operation.

Nor will such policy necessarily militate against progress along

industrial lines. New principles are indeed rare and new inventions are, as a rule, but new applications of the old principles. Out of the innumerable new things comparatively few stand the test of time, and the great majority are rejected without trial because of too evident defects. Most large establishments are but a combination of well-known details, whose indiscriminate or arbitrary selection, however, would hardly have inured to success except possibly at excessive cost. In any event their determination on the basis of previous reputation is a safer policy, which in view of definite knowledge as to past failings and the specific modifications desired is more certain of actual progress at a minimum of expenditure.

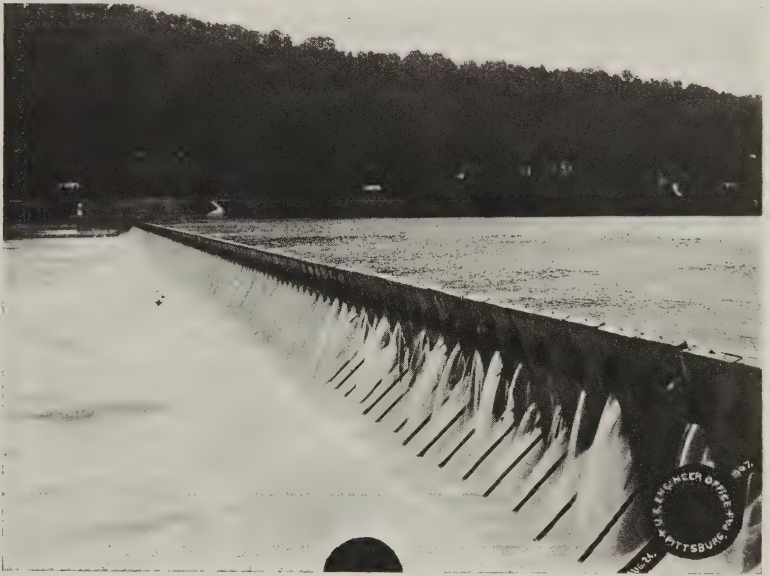

Fig. 1. Dam No. 2 in raised position; length of wickets, 17 feet $10\frac{5}{8}$ inches

However, the foregoing observations are not intended as antagonistic to the adoption of any really meritorious new device or scheme. This age has achieved many mechanical and structural successes well worthy the effort and cost, and will no doubt add others of equal worth. On the other hand, they are merely offered as a caution against an over-indulgence in new experimentations made up in large measure of old, tried-out and condemned devices or contrivances, unmindful of the fact that these have been elimi-

nated through the operations of a long sifting process resulting always in the survival of the fittest.

In this connection it is significant that along many lines of structural and industrial activities special attention is now given to classifying and standardizing their constituent parts. With much the same end in view the United States Engineer Department has established permanent boards of engineers on various systems of improvement. This practice should add materially to the existing high standard of navigation works by a further reduction of the less desirable elements in them, as well as by the acquisition of such as give promise of maximum serviceableness.

While original construction has its difficulties, vexatious delays and mishaps, so none the less is maintenance and operation fraught with anxieties, hardships and perplexing problems. Not that it is always so, yet since these conditions are often unanticipated the strain of vigilance may seldom with safety be relaxed. However, in many respects the adverse conditions pertaining to these two departments of work differ widely. In the former as far as possible the work is performed within cofferdam inclosures under the most favorable river conditions obtainable, and every other interest, navigation or otherwise, is made to submit to the utmost. When rises occur the work ceases; when winter approaches the earliest opportunity is seized to suspend operations; flood and breakage repairs are made at leisure, and so on. In a word, the builder is supreme, and yields only such consideration to others as his interests can well afford. Abnormal freshets, ice, etc., are always urged as a sufficient cause for a liberal extension of the contract time limit.

Under operating and care practically the opposite conditions obtain. Built for purposes of navigation the structures are placed in commission and are expected to fulfill their mission. Regardless of deficiencies, the demands of navigation are now upon them and must be accommodated. Unusual circumstances no longer furnish a sufficient excuse for material delays in their prompt maneuvers when needed. Those defects and weaknesses which almost invariably develop in the early stages of all new structures must be overcome without undue interference with their continuous operations. Breakages, generally guaranteed by constructors not to occur, must be repaired or temporarily stayed, often under unfavorable conditions and within restricted time limits. On such occasions the cofferdam is usually a diving suit, and when the method and appliances for doing the work have been determined upon the under-

taking is well-nigh accomplished. Eventually such repair and renewal operations result in a complete rehabilitation of the structures either in part or whole.

The principal conditions ordinarily affecting the operation and maintenance of Ohio River locks and dams may be divided as follows:

River fluctuations;
Drift;
Ice;
Ordinary breakages;
Unusual breakages and casualties;
Renewals.

RIVER FLUCTUATIONS

Were the Ohio susceptible of such improvement as to furnish at its head a minimum open-river navigation of 5 to 6 feet at all times, slackwater would hardly be a necessity. On the other hand, were its maximum freshets on the upper reach not to exceed about 25 feet, thus obviating the inundation of valuable lowland interests, the stream would doubtless have been improved long since by a system of fixed dams. As it is, with no navigable water in open river much of the time, a sufficient stage for heavily laden craft during only a comparatively short period annually, and this widely scattered, with not unfrequent floods covering vast areas of bottom lands and with a transportation system peculiarly adapted to meet these periodical conditions, the movable dam system adopted seemed to be the only available expedient, at least until the accomplishment of an adequate flood prevention or regulation, if such a thing should prove practicable.

But the very conditions which compelled the adoption of movable dams are at the same time also their greatest menace. While occasionally there occur seasons of limited fluctuations the majority abound in rises so erratic as to keep the movable features of dams almost continually in action. The greater the number of rises, necessarily the more difficult and arduous the task of maintaining and operating, due at the same time to increased maneuvers, injuries and river traffic. Experience has enabled the passage of approximately an 8-foot open-river stage at Dam No. 1 and a 10-foot stage at Dam No. 6 without lowering the navigable passes of the series. Hence, since the majority of summer and autumn rises fall short of this height, the bulk of the work is confined to pool regulation,

involving needle placement and removal, bear-trap gate maneuvers, weir-wicket maneuvers, calking with brush, straw and ashes during droughts, etc. Almost invariably some of these operations form a part of the daily routine. To be sure, the raising and lowering of the wickets of navigable passes is the most difficult part of the operation of these structures; but pool regulation involves much greater labor, some of which, as needle placing, is also more dangerous to the operator.

When a sufficient rise occurs the dams must go down, not merely to make way for increased discharge, as was originally done, but in such manner that transformation from pool to open river will be least appreciable and will work the minimum hardship and inconvenience to navigation interests. This for an isolated structure is not difficult, but in a considerable series of dams it is. First of all, the probable result of a given precipitation condition must be correctly estimated together with its rate of progress, time of arrival, etc. Then, when the rise approaches the maneuvers of the several dams with relation to each other must be carefully directed in order that none may be overwhelmed by the combined waters of the natural and artificial rises. But the foregoing applies more especially to normal rises, that is, rises which give reasonable notice of their coming. In view of the fact that no two rises come in the same manner each must be worked out on its merits. To accomplish this with reasonable accuracy there must enter into the consideration the season of year as to evaporation and vegetation, condition of the ground, snow, ice, and frost, if any, state of river at time of rainfall or snow melt, generality of rainfall and whether heavy or gradual, etc. Since, at the head of the Ohio there are two large tributaries with their sources in precisely opposite directions and at times under wholly different meteorological influences, favorable conditions exist for occasional abnormal developments, including rises giving no warning of their approach. Such rises have occurred within eight hours from beginning of rain to completion of dam maneuver and development of 10-foot open-river stage. It being impossible to anticipate such phenomena, the only safeguard against a surprise is to regard each summer storm as abnormal until proven otherwise.

Perhaps one of the most difficult problems for solution is that pertaining to successive rises. At a comparatively low stage of water a surprise is improbable. But should the maximum stage occur at which the dams may be kept standing, and this condition

be met by an extraordinary local rainfall, opportunity is then afforded for an increase so sudden as to almost baffle all efforts to lower dams at all. This condition is seldom lacking in a season's operation.

Another singular condition at the head of the Ohio is the development of the majority of rises at night. The heavy summer storms usually occur in the late afternoon or evening, while heavy fall and winter rains occur more frequently at night. Accordingly, the amount and extent of summer precipitation must often be determined at night when the usual facilities for such information are not available and the observations and reports obtainable are for obvious reasons less reliable. Instances are on record when within recent years it became necessary to secure such information from railroad conductors and station agents and the night employees of other institutions having little knowledge of such matters.

Fig. 2. Dam No. 6 in raised position, showing 600-foot Chanoine wicket navigable pass and two 120-foot bear-trap regulating weirs

DRIFT

Although not nearly so serious a consideration as formerly, owing to a material decrease in the quantity consigned to waterways, yet, on the whole, drift must always be reckoned with as an important factor in the operation of movable dams. Even when rainfall is moderate and unproductive of rises its accumulation above Ohio River dams is considerable, requiring frequent and at times daily

removal. However, excessive local rainstorms bring large quantities of drift out of nearby tributaries and much time is consumed in its disposition in order to prevent interference with the movements of maneuvering boats and needle flats in anticipation of wicket maneuvers. When the needles are off, drift is drawn into the spaces between wickets and is hard to remove when they require replacing; it clogs and forms objectionable drift dams in weir service bridges, especially when wickets are down; it interferes greatly with maneuvering boat movements when lowering wickets, frequently gathering in such quantities as to overtax the capacity of the powerful capstans provided for hauling boat back from open pass gap, and the larger pieces after passing through or over dams become entangled among the wicket horses and props, greatly interfering with the lowering process, especially at night.

One of the worst features of the drift problem lies in the fact that everything released at one structure only passes on to harass the next. This has led to consideration of the advisability of its permanent disposal at proper intervals to avoid unnecessary rehandling. Doubtless, some such scheme will be adopted as the number of improvements increases. Everything from whole trees of large size, logs, frame timbers, barrels, boxes, kegs, bales of hay and straw, down to trifling twigs, excelsior, etc.; in fact, anything that will float, may be found in the drift gorges. Quite naturally, too, drift is always most plentiful and hence most troublesome when rises are most numerous, necessitating more frequent dam maneuvers.

ICE

While in point of duration the element of ice is a minor factor, yet for the time it is doubtless the most dangerous one to the movable dams. Happily, when the dams are down it furnishes no special cause for alarm except to urge additional attention to the floating plant. Whether or not, therefore, it enters into the field of operation depends altogether upon the stage of river at the beginning of winter. Should the water continue at sufficient height for open river navigation after hard freezing weather sets in—usually any time after the middle of November—so that the dams may remain down, this feature is practically eliminated. But, if on the contrary a comparatively low stage of water prevails, requiring the dams in raised position, as in the past three years until January, it immediately becomes an added perplexity.

Commencing at upstream side of dams the pools gradually close solidly with ice, attaining, according to temperatures, to several inches in thickness. Through this the steamboats break their way, much of the broken ice following their trail to the locks and dams there to add to the unwieldinesss of the mass. The spray from overflow and leakage between wickets creates heavy ice formation on downstream or under surface of wickets above lower pool submergence line. The added weight to top of wickets causes them to breach when, eventually, the pool head is released, thereby encouraging ice gorges in the horses, interfering materially with maneuvering boat movements and otherwise greatly hindering and belaboring the lowering process. While the dams stand and winter progresses the disadvantages under which the operating force is working increase. Everything becomes ice covered, especially the pool regulating needles, handled mainly by hand, and the ropes, oars, poles, wicket hooks, etc., and the effect of low temperatures accompanied by wetness becomes depressing.

Fig. 3. Raising wickets of navigable pass in Dam No. 1 (Davis Island Dam)

Necessarily, the crucial test comes with the final lowering of the ice-bound dams. Meanwhile, the mountain tributaries have closed with heavy ice and an accumulation of snow covers the watersheds.

These will move out with the first material thaw and rain and the dams must of necessity be out of the way or suffer the risk of destruction. But with the pools covered with ice they can not be lowered in the usual way, else the local ice will move down on the dams and demolish the operating plant, leaving the dam to the mercy of the ice and flood from above. Having determined to permit the dams to stand into the winter, as has been done during three successive seasons, proper discretion must be exercised to avoid ill-advised premature lowering in view of the fact that upper-river ice movements repeatedly threaten before finally disgorging. To successfully dispose of the movable structures it is essential first of all that a careful watch be kept on meteorological conditions, keeping in close touch with the United States Weather Bureau, not occasionally but continually, to enable the determination of the peculiar storm characteristics which develop in some instances non-rise producing dry or cold storms and at others warm or rain-producing storms, certain of resulting in a winter freshet. It is essential, too, that these phenomena be sighted far enough ahead to permit of performing the necessary wicket maneuvers in advance of ice movements liable otherwise to gorge on the dams and destroy them.

Necessarily, the process of lowering with frozen pools is considerably slower and requires from two to four days for even the present series of seven dams. That this implies apparently a limited application of the policy of extended winter operations is not a new discovery, for it has always been admitted that Chanoine dams are not well adapted to ice maneuvers. Nevertheless, a short experience has shown that under careful management they are suceptible of valuable winter service. Although on several occasions upper end and intermediate structures have been lowered first, the logical plan is to begin at the lowermost dam. Proceeding upstream each pool is carefully drained as speedily as practicable without moving its ice. After the head has been released the wickets are quickly lowered to place. Two structures in twenty-four hours is about the limit of progress. Frequently isolated pools temporarily used for deep draft harborage purposes are maintained. Thus, with the standing dams reduced to a minimum the oncoming rise and ice from above are awaited and these structures lowered in time to avert damage. The upper river ice has been permitted to approach within less than 25 miles of Dam No. 1 and the lowering process safely completed before its arrival and without effecting sufficient change in the water level at Pittsburg to disclose the operation.

However, no definite rule can be laid down for such maneuvers, and each separate condition must be treated to meet existing circumstances.

Having determined upon part winter operation of movable dams, the possibility of failure to lower in advance of up-river ice movement dare not be entertained. Accordingly, owing to liability of defeat of above-described method a reliable alternative must be available. Heretofore when either ice or sudden freshets have menaced structures in raised position a steamboat has been hurried to the rescue and by means of an empty flat has lowered them from the downstream side by pushing against the wickets until props were unseated, then releasing and permitting them to drop. While almost unfailing in its results this has been objectionable because of rough usage of movable parts—bending horses, breaking horse boxes, shearing anchor bolts, etc. However, there is no serious doubt but that the employment of a Government steamboat more specially adapted to the work and manned by experienced dam operators, instead of disinterested boatmen, will readily develop this into a perfectly safe operation for emergency cases.

ORDINARY REPAIRS

Among works of similar magnitude Ohio River locks and dams with their operating plants are no exception to the rule of constant minor breakages and deterioration. Machinery parts of every description break or wear out; operating devices suffer injury; lock and gate valves become unmanageable or broken; gate wheels, chains, and operating gearing break; horse boxes, horses and props break or bend and wickets get away; floating plant is damaged or becomes leaky; scour and foundation settlement occur, etc. Admittedly, many of these are insignificant, while others are extensive and difficult to manage. Generally, such repairs are made as breakages occur, yet oftimes this is inexpedient. As far as practicable the dams are kept intact. As movable parts become damaged or disarranged they are replaced by extra parts kept in stock for the purpose and the injured parts are repaired at leisure. Where immediate attention is impracticable, single wickets are bridged with heavy planks supported by adjacent wickets. However, when two or more adjoining wickets become inoperative it is generally necessary to replace or repair all but one before closing dam. Necessarily, most underwater work must be performed by divers, their labor being reduced to the minimum by forces above water. As a

rule, dam repairs can not safely be made with dam up, owing to excessive current and danger of near wickets dropping. Since wicket breakages are usually discovered when raising dam it becomes necessary often, if structure is nearly up, to again lower it partially in order to accomplish the work safely.

UNUSUAL BREAKAGES AND CASUALTIES

Practically all constructions, regardless of care exercised in their design, erection, maintenance, and operation, are attended by more or less of disastrous happenings. Then, too, every part of such works must ultimately reach its limit of service through deterioration or otherwise. Unless, therefore, an organized repair force be maintained all work in this connection will ordinarily devolve upon the operating force, and in any event upon the operating and maintenance department. The nature of such casualties covers a very wide range, involving practically everything pertaining to locks and dams up to their eventual rebuilding. A few prominent instances will, perhaps, best serve to show its character and importance on these structures and incidentally to demonstrate the remarkable fortitude of certain features to perform their functions in a reasonably satisfactory manner notwithstanding extraordinary breakages and deterioration.

In the construction of Dam No. 1, Allegheny River, the first steel bear-trap gates were introduced, two in number, each 94 feet wide. After placing the structure in commission these gates failed to rise. Every practicable expedient was tried: one of the intake culverts changed to opposite side of pier, temporary deflecting fenders built below intakes, etc., but all to no avail. Finally, while awaiting delivery of cofferdam material, looking to an abandonment of bear-traps and the substitution of Boulé weirs, a further experiment was made for reduction of leakage between leaves. This resulted in their successful operation and the culmination of what is now one of the most satisfactory and valuable features of the movable dam system.

Dam No. 1, Ohio River (Davis Island Dam), may be rightly said to have been the movable dam experimenting station, where have been worked out most of its perplexing problems. These include the building, in 1887, of the first bear-trap gate. As a drift disposal gap it failed, but instead developed this now indispensable regulating weir. It was reconstructed in 1906 of composite—wood and steel—construction. The original wooden lock gates gave place to steel gates in 1897. The gate operating gearing and ma-

chinery underwent several changes and has been materially increased in strength. The power plant was changed from hydraulic to steam. Timber guide walls were reconstructed of concrete. Practically all of the movable parts of dam have undergone important modifications and been renewed. The weir service bridge has been rebuilt, an improved maneuvering boat built, and almost innumerable minor changes made. While some of this work has been performed under contract, much the greater part was done by the operating force.

One of the most common breakages on this structure has been lock-gate axles and wheels. The gates now in use are about fourteen years old, and being the first steel rolling gates are naturally not up to the standard of the later gates. Each gate is supported by fifteen pairs of wheels, which are fixed on axles passing through lower ends of main gate posts. The gate track gauge is 11 feet 6 inches, the rails being flat. The gates are drawn into and out of their recesses by means of 1¼-inch chains wound around grooved chain drums, operated by two cylinder engines. When the dam is up, often from April until end of year, the number of lockages is approximately 650 monthly for several months during the season.

Fig. 4. 6,000-ton lockage of coal in barges passing through Lock No. 2. Lock will pass 12,000 tons if loaded in coal boats drawing 9 feet

A conservative estimate would probably place the annual gate travel of each gate at about 100 miles, which is a severe strain on old gates, of which practically no care can be taken save a hasty annual overhauling in the winter. The axles usually break just inside their journal boxes, while the wheel breakages follow no particular rule. Similar breakages do not occur on later gates, whose axles, however, are very much heavier and have loose wheels. No special reason has been discovered for these breakages at Dam No. 1, save that the axles are probably too light for the work.

As the breakages occur gradually, frequent examinations are made by divers; broken axles supported by chains or otherwise, and broken wheels removed, etc. Beyond this, little or nothing can be done until the annual winter repair season, unless a gate becomes entirely disabled. Usually, they can be made to run through the season. However, in 1910 the upper gate became so badly disabled as to necessitate its suspension in October. Since Pool No. 2 can be made to maintain within about 2 feet, the normal pool stage at Pittsburg navigation was not seriously affected by the temporary lowering of Dam No. 1. At time of suspension the condition of upper gate in detail was as follows, beginning at outer end:

Truck No. 1. In good condition.
Truck No. 2. In good condition.
Truck No. 3. Lower wheel broken.
Truck No. 4. In good condition.
Truck No. 5. Axle broken.
Truck No. 6. In good condition.
Truck No. 7. In good condition.
Truck No. 8. In good condition.
Truck No. 9. Axle broken.
Truck No. 10. Both wheels broken.
Truck No. 11. Axle and both wheels broken.
Truck No. 12. Both wheels broken.
Truck No. 13. Axle and both wheels broken.
Truck No. 14. Axle and both wheels broken.
Truck No. 15. Both wheels broken.

Thus, of a total of fifteen axles five were broken, and of thirty wheels thirteen were broken. In addition, there were also several broken journal boxes and eight upper gate posts were entirely or partly rusted through at the water line. While the wheels were not entirely broken into pieces, yet they were so badly damaged as to require replacing with new ones. That a lock gate in such con-

dition should still be capable of making a lockage seems altogether unbelievable. Where wheels are fixed to axles, as in this case, the gates must be raised about 40 inches and adjacent valve frames removed in order to release and replace trucks. The field work of all repairs of this nature is always performed by the lock forces.

In Dam No. 6, Ohio River, there were originally constructed two bear-trap gates, each 120 feet wide by 13 feet 2 inches vertical height (among the largest ever built). Their design—steel frames filled in with wood—involved the first radical departure from wooden bear-trap construction, theretofore deemed essential to their successful operation on account of buoyancy. They were given a test trial, in 1904, and found to be so flexible as to forecast but a brief existence. In fact, their collapse at any time was considered imminent. However, it was decided to use them as long as practicable. When down, during their latter stages, it was always a question whether or not they would rise again. Finally, in 1909, both lower leaves broke in two about midway between piers. Although still serviceable and performing their functions reasonably well, their reconstruction was undertaken immediately and completed early the following season. This rebuilding consisted mainly in the removal of the wood filling and covering of the steel frames with buckle plates, so that in their present state the gates involve the essential features of the later steel bear traps and are equally satisfactory. While under reconstruction the remainder of dam was in raised position part of the time, and could have been kept in operation practically all the time. Except the structural steel work, for which a contract was let, the work was performed by the operating force. This, it will be observed, furnishes another instance showing the extent to which an important structural feature of a dam may be injured or disrupted and yet be made to continue in active service.

RENEWALS

Notwithstanding that in time every part of the movable dam structures will require rebuilding, the extensive use of modern steel in many of their important features will hasten the need for renewals alarmingly, rendering these an essential factor in maintenance and operation. In order to avert vexatious interruptions to navigation, if not indeed costly disasters to both it and the Government, perhaps the most difficult question in this connection will be the determination of the proper time for abandonment and re-

construction of certain important parts. For instance, the life of steel lock gates is likely to be short, and to insure continuous navigation their removal must be anticipated a year in advance. So, in a measure, too, the replacing of bear-trap gates, service bridges, maneuvering boats, etc. As a more notable example will come the reconstruction of Dam No. 1. This was the initial, and to a considerable extent experimental, structure, erected thirty years ago, and lacks many of the essential qualifications of the more modern dams. Furthermore, it has been subjected to severe usage, causing many breakages in the floor, sill, anchor bolts, etc.; is equipped with an objectionable hurter; has no protection structure along downstream edge and, above all, under the 9-foot navigation scheme furnishes only a 3-foot head over Pool No. 2, rendering its operation exceedingly difficult under certain stage conditions. These defects, it is believed, can together be remedied most satisfactorily and economically by rebuilding.

Experience has pretty fully demonstrated the impracticability of maintaining a system of locks and dams without interrupting navigation while accomplishing important repairs and constructions under contract. Ordinarily, contractors are suspicious of repair jobs and bid accordingly. It is evident the risks contingent on the preservation of navigable pools during construction operations are inconsistent with reasonable contract prices to the Government. Then, too, contractors do not look with favor on winter river operations, which of necessity are most advantageous to slackwater repairs and renewals. Hence, it has been found desirable to perform all work possible by the operating forces and additional hired labor, letting only shop and such field work as will not prove detrimental to movable dam operations.

Whilst omitting mention of many important maintenance and operating requirements applying to Ohio River movable dams the foregoing will doubtless suffice to emphasize the necessity for superior qualifications in those responsible for their direct supervision. The lockmaster in charge of a million-dollar structure and operating plant, although not left entirely to his own discretion, must nevertheless combine more than ordinary executive ability, sound judgment, and resourcefulness with practical experience as an all-round riverman, machinist, mechanic, concrete worker, and general construction overseer capable of performing any character of river work under unfavorable and abnormal conditions within exacting time and economical cost limitations. And, above all, he

must be fearless within reasonable limits and absolutely trustworthy and reliable. So, also, in order that the work be accomplished properly, must his assistants be equipped, at least in measure, with similar qualifications.

Movable dam operations have now extended over a period of more than three years on a series of seven consecutive dams in the Pittsburg engineer district, while with a lesser number combined with their construction more than thirty years experience is had. With an increase in number of dams will also, doubtless, arise new problems applying especially to the enlarged system. Others, too, affecting individual structures will no doubt develop. Yet it is probable that the majority of difficult questions have already been met and by giving attention to occasional new conditions as they occur the perfecting of the entire Ohio River system will eventually be accomplished. Meanwhile, the greatest danger to the works would seem to lie in an assumption that the situation has been so fully mastered as to render failure impossible. So long as nature is known not to have exhausted her resources to produce new conditions or combinations eternal vigilance will probably furnish the surest safeguard to the preservation of these navigation interests.

A SYSTEM FOR FILING AND INDEXING PROFESSIONAL LITERATURE

BY

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In order to keep track of the numerous books, pamphlets, catalogs, mimeographs, etc., that are sent to the officers of the Corps of Engineers, some system of indexing and filing is necessary.

The system described below was originally devised by Maj. H. B. Ferguson, Corps of Engineers, in 1903, assisted by Maj. W. D. Connor, Corps of Engineers, and the author.

The system is so simple, flexible, and convenient that it is believed a description of it may be of some aid to the officers of the Corps, especially the junior officers, in arranging their professional papers.

The index is kept on cards, 3 by 5 inches, in a file or cabinet. It is probably best to commence with a single-drawer cabinet which will hold about 1,000 cards.

The following decimal classification may be used:

1. FORTIFICATION—
  11. Coast Defense (See 86):
    111. Navy and Naval Defenses.
    112. Power Plants. (44, 60.)
    113. Fire Control.
    114. Emplacements by Caliber.
    115. Ammunition Supply.
    116. Damp-proofing.
    117. Submarine Mines and Torpedoes. (See 6.)
    118. Magazines. (See 115.)
119. Lighting. (61.)
  12. Land Defense:
    121. Permanent.
    122. Semi-permanent.
    123. Field. (See 70.)
    124. Siege Works. (75.)

2. WATERWAYS—
  21. Construction Common to Various Classes:
    211. Bank and Shore Protection.
    212. Boats and Dredges.
    213. Dredging and Fill. (422.)
    21. 2131. Rock Excavation.
    214. Piers. (4211.)
      2141. Ice Piers.
    215. Wharves and Docks.
    216. Dikes.
    217. Removal of Wrecks.
    218. Rip-rap.
  22. Rivers:
    220. Canalization.
    221. Regularization.
    222. Dams.

- 223. Locks.
  - 2231. Lock Keepers' Houses. (424.)
- 224. Training Walls.
- 225. Levees.
- 226. Reservoirs.
- 227. Floods.
- 228. Snagging.
  - 2281. Water Hyacinth.
- 229. Diversions and Cut-offs.

23. Harbors:
- 231. Breakwaters.
- 232. Bulkheads.
- 233. Sea-walls.
- 234. Jetties.

24. Canals:
- 241. Locks. (223.)
- 242. Wiers.

25. Light Houses.

26. Water Power. (222, 226.)

27. Irrigation.

28. Forestry.

3. ORDNANCE—
- 31. Guns:
  - 311. Small Arms.
  - 312. Machine.
  - 313. Field.
  - 314. Siege.
  - 315. Fortress and Sea-coast.
  - 316. Mortars.
  - 317. Howitzers.
  - 318. Naval.
- 32. Armor.
- 33. Explosives. (48, 74.)
- 34. Ballistics.
- 35. Ammunition.
- 36. Gun Carriages.

4. GENERAL ENGINEERING—
- 41. Mechanics.
- 42. Construction:
  - 421. Bridges, Viaducts, and Culverts.
  - 422. Excavation and Fill.
  - 423. Foundations.
  - 424. Buildings. (2231.)
  - 425. Highways.
  - 426. Concrete. (424, 431.)
  - 427. Masonry.
  - 428. Retaining Walls.
- 43. Materials:
  - 430. Tests.
  - 431. Cement and Lime.
  - 432. Metals.
  - 433. Paints.
  - 434. Stone.
  - 435. Sand.
  - 436. Wood.
    - 4361. Wood preservation.
  - 437. Fuel.
  - 438. Glass.
  - 439. Brush.
- 44. Plant:
  - 440. Pumps.
  - 441. Engines.
    - 4411. Steam.
    - 4412. Gas or Oil.
  - 442. Boilers.
  - 443. Tools.
  - 444. Machines.
  - 445. Conveyors.
  - 446. Derricks, Cranes, etc.
- 45. Municipal:
  - 450. Water Supply.
  - 451. Sanitation.
- 46. Railroads:
  - 461. Steam.
  - 462. Electric.
- 47. Mechanical. (44.)

8. Mining. (33, 74.)
- 49. Marine. (111.)

5. SURVEYING—
- 50. Topographic:
  - 501. Sketching. (76.)
- 51. Hydrographic.
- 52. Geodetic.
- 53. Explorations.
- 54. Geography.
- 55. Maps.
- 56. Photography.
- 57. Lithography.
- 58. Drawing.
- 59. Astronomy.

6. ELECTRICITY—
- 60. Power. (112, 26.)
- 61. Lighting. (119.)
- 62. Motors.
- 63. Dynamos.
- 64. Storage Batteries.

- 65. Search Lights.
- 66. Communication.

- 7. Military Engineering (1)—
  - 70. Duties of Engineer Troops.
  - 71. Bridges. (421.)
  - 72. Roads. (425.)
  - 73. Railroads. (46.)
  - 74. Demolitions. (48.)
  - 75. Sieges. (124, 48, 33.)
  - 76. Reconnaissance. (50.)
  - 77. Maneuvers.
  - 78. Camps.
  - 79. Equipment.
- 8. Art of War—
  - 80. Military Geography. (54.)
  - 81. Organization.
  - 82. Tactics:
    - 821. Security and Information.
    - 822. Map Problems.
    - 823. Map Maneuvers.
    - 824. Terrain Exercises.
    - 825. Tactical Rides.
  - 83. Strategy.
  - 84. Logistics:
    - 841. Transportation.
    - 842. Subsistence.
    - 843. Signalling.
  - 85. Staff Duties.
  - 86. Military History by Date.
  - 87. Maneuvers.
  - 88. Military Notes.
- 9. Administration—
  - 90. Cost Keeping.
  - 91. Civil:
    - 911. Civil Employees.
    - 912. Civil Service.
  - 92. Military:
    - 921. General Orders and Circulars.
    - 922. Annual Reports.
    - 923. Army Lists.
  - 93. Law:
    - 930. Constitutional.
    - 931. Military.
    - 932. International.
    - 933. Improvement of Rivers and Harbors.
    - 934. Bridging Navigable Waters.
    - 935. Contracts.
  - 94. Transportation. (841.)
  - 95. Specifications.
  - 96. Contracts.
  - 97. Advertisers and Advertising.
  - 98. Office Equipment.

This classification is not complete, but it serves as a guide and will have to be amplified from time to time by the individual adopting it. Its present form is the result of seven years use by the author, during which time it has been thoroughly tested and found of great advantage when desiring to find any book or pamphlet or to look up the literature on any subject. It also takes very little time to mark a book with the proper numbers to indicate the different subjects treated in it.

A much more complete classification may be found in "Classification and Index," M. I. D., No. 37, 1903. The objection to such a system is that the numbers have so many places that they are hard to remember and take too much time and space to mark on papers and books, and the classification is not as convenient or simple for an individual's papers.

The decimal system is preferable to an alphabetical system as the latter permits of only twenty-six general classifications, while the former allows an indefinite number. Then, again, it is much easier to mark a paper with a short number than with a word or

title that may be necessary to describe its contents. With the decimal system, the first place of the number gives the general classification; the second place, the main subdivisions under this class; the third place, the secondary subdivisions, etc. For example, if you have a pamphlet dealing with floods, you would know that it should be classified under waterways (2), and under the subdivision of rivers (22); then, looking at the guide card in your file, you would find that floods are classified under 227.

The indexing cards should be marked with a number on the upper right-hand corner showing the classification to which they belong, and should contain the titles and descriptive notes of the books or papers indexed under this classification. In addition, there should be a number of guide cards which have a projecting tab, on which should be marked the classification and the number corresponding to it. For example, there should be a guide card marked "2. Waterways" on the tab; then, on the body of the card, should be marked the different subdivisions of waterways given above. This card may be consulted when it is desired to find the number that should be placed on a paper pertaining to waterways and on the card indexing this paper.

Papers, pamphlets, etc., should be filed in accordance with the above system of classification. Bound volumes are usually placed on shelves or in boxes in sets, such as the reports of the Chief of Engineers. These it is not advisable to index, but they should be arranged serially by years, and a list of the contents of each box should be kept in the card file. Good descriptions of engineering details that may have been noticed in these books may be indexed in the card file.

A convenient size for book boxes is 3 feet by 10 inches by 8 inches deep, inside dimensions. When the covers are removed these boxes form convenient book shelves and obviate the packing and unpacking of the books.

Bound volumes not in sets should be numbered, preferably on the back, according to the decimal system given above, and they should be placed in a box with the other books of this classification, or in the proper order on the book shelves. These books should be indexed under the number or numbers marked on them.

For example, "The Improvement of the Mississippi River," Occasional Papers, No. 41, Engineer School, should be marked

"221" (river regularization) and placed in a box with other books of that number. The corresponding card in the index file should be marked "F 221" in the upper right-hand corner, showing that the books described on the card are filed under that number; that is, in a box with other books of that number. The following should be written on the card: "1. Mississippi River—Winslow, 1910, 2 vols., maps."

The same card might have the following on it also:

"2. Missouri River, H. D. 1120, 1908, Schulz, maps."

"3. Connecticut River, H. D. 867, 1910, Taylor, maps."

In the case of the first-mentioned book it would be well to mark and index it under 211 (bank protection), 216 (dikes), 225 (levees), etc. That is, a card should be marked "211" in the corner and the following notation may be placed on the card:

"1. Mississippi River—Winslow, 1910, 2 vols., maps. F. 221." Showing that the book was filed under 221.

Thin pamphlets and House of Representatives documents should be numbered according to the classification to which they belong, and should be placed in numbered envelopes or filing cases. These envelopes or cases may be kept on shelves or in boxes, all of one number together. Oil boxes are convenient for this purpose. The important pamphlets and documents should be indexed as shown above. It is a great advantage to have written on the outside of the documents the numbers showing the classes of work described or reported upon, as the titles do not usually indicate this.

For example, H. D. No. 558, 1910, entitled, "Civilian Engineers" should be numbered 911 and placed in an envelope with that number plainly marked on it. This envelope should be kept in a box with other envelopes or books marked 9. The pamphlet, "The Influence of Forests on Climate and on Floods," by W. L. Moore, should be numbered 227 (floods) and indexed and filed under that number. It might also be noted on a card numbered 28 (forestry).

When there are a large number of documents on one subject as 213 (dredging), they may be arranged geographically or by districts.

Mimeographs should be kept together, each number with its supplements, and arranged in order in the large mailing envelopes marked with the numbers they contain. It is best to keep the mimeographs in one set of envelopes and the large drawings folded in another set. The envelopes may be kept in oil boxes. In-

dexes are sent each year, but it is an advantage to have them indexed in the card file.

For example, a card numbered 113 (fire control of seacoast defenses) might have the following notations:

"1. Speaking tubes for batteries.........Mim. 48-s. 49.
"2. Electric lighting of F. C. stations....Mim. 131.
"3. Circular benches for O. S., D. P. R. F. Mim. 42-s. 58."

The second might also be on a card numbered 119 (lighting).

Specifications should be numbered according to the class of work to which they refer, and then should be arranged in order in an oil box. When a great number of one class accumulate they may be sorted over and some thrown away.

Maps and charts should be indexed under 55 and filed in a flat box about 30 by 42 inches by 4 inches deep. They should be numbered in the order in which they are placed in the box, and these numbers placed on the index cards. The cards numbered 55 should be arranged according to the class of work illustrated by the drawings indexed on them. For example, a card marked 55 may contain the following:

"MAP BOX

"Waterways 2.

"Order in box.
"1. Chicago River Atlas.......................... 4
"2. Kampsville Lock and Dam, Ill. R. (14 plates).... 5
"3. Lock and Dam, St. Marys Falls (18 plates)...... 19
"4. Tables showing important features of construction cost of U. S. Locks and Dams................ 54."

The card index may also be used to index books and articles that have been read or noticed. The favorable book reviews in engineering periodicals furnish a valuable list of the best current books.

The lists of "Selected Articles of Engineering Interest," published in the PROFESSIONAL MEMOIRS, may be cut out and pasted on cards numbered according to the above system and kept in the card file, furnishing a valuable index of engineering literature. The Proceedings of the American Society of Civil Engineers contain a more complete list of engineering articles. A similar list of military articles is published with each number of the Artillery Journal. All of these are printed on one side of the paper, so that they may be pasted on cards.

COMPARATIVE METHODS OF EARTH EXCAVATION AT COLBERT SHOALS CANAL

BY

Mr. CHAS. E. BRIGHT
Superintendent

Colbert Shoals Canal, which was designed to overcome the obstructions to navigation at Colbert and Bee Tree Shoals, is located along the south, or left bank, of the Tennessee River; the lower end of the canal being about one-half mile above Riverton, Ala. It is a lateral canal 8 miles long, with a lock of 26-foot lift, 80-foot width, and 350-foot length, located at the lower end. Beginning at the upper end of this lock and extending upstream for a distance of 5.3 miles, the canal was excavated through the bottom lands, the cutting ranging in depth from 17 feet at the lower end to 20 feet at the upper. Above this, by reason of the close proximity of the bluffs to the water's edge, the canal was formed by building a concrete wall in the river about 180 feet from the left shore line, for a distance of 1.4 miles, and above this, on account of its being more economical than excavating through the bottom lands as originally proposed, the river side of the canal was formed by building a levee in the river with the material excavated in bringing the canal to the required depth.

As the excavation of the canal for 5.3 miles through the bottom lands is the only portion of the canal to be considered in this paper, the formation, topography, location, and character of that material will be described.

The bottom lands are of an alluvial formation, and as is usual along silt bearing streams, are highest near the top of river bank, sloping gradually from this point to the foot of the hills. It is presumed that the canal was located close to the foot of the hills for the purpose of reducing the quantity of excavation. As is natural to suppose, the expensive material was found mostly on the side of the canal next to the hill, and part of the canal was so close to the hills that no material could be deposited on the land

side of the canal. This necessitated the wasting of all material on the river side of canal, which increased the haul by teams and also caused some of the material to be handled twice, when using the drag-bucket excavators. With the exception of a distance of about 1,300 feet, where the slope stakes are within a few feet of the top of the river bank, there is a strip of bottom land between the present location of the canal and the river which varies in width from 400 to 700 feet. This provides ample room for the location and also permits the elimination of several curves, and though this ground is slightly higher than that through which the canal now runs, the additional expense of handling the increased yardage would have been more than counterbalanced by the cheapness of removing the drier and softer material.

The cross section of the canal is 112 feet wide at the bottom or at grade, with side slopes of 1 on 2. Berms 15 feet wide between slope stakes and the toe of spoil banks were left on both sides of the canal, the berm on the river side being brought to a height of not less than 9.5 feet above low water in the canal.

The excavation for forming the canal trunk between the upper end of the lock and the lower end of the concrete wall was made under four separate contracts, as follows: The first covering Stations 10-110, and the second covering Stations 110-210, were dated October 12, 1905; the third, covering Stations 210-260, dated March 12, 1905. All of the above contracts were awarded to Shippey & Outzen, Memphis Tenn., at 17.49 cents per cubic yard for earth, 50 cents per cubic yard for hardpan, and $1 per cubic yard for rock, the price for the last two items being fixed by the Government. The fourth contract, covering Stations 260-290, dated April 7, 1908, was awarded to W. A. Shippey and the North Alabama Construction Company, at 24.9 cents per cubic yard, unclassified.

The work of excavation was commenced November 15, 1905, immediately above the lock, with wheel scrapers and Western elevating grader, drawn by traction engines, and served by Aurora dump wagons of 1½ cubic yards capacity. As the grass and cornstalks clogged the elevator of the grader, it was necessary to use the wheel scrapers to strip the surface before the graders could be successfully used. On account of the soft, sticky condition of the material, being what is usually termed "gumbo," it was soon learned that the elevating graders were not adapted to the work, and arrangements were made by the North Alabama Construction Company, sub-contractors, Stations 10-135, for installing Arm-

strong excavator machines using the Page drag bucket. Two of these machines were erected and began work on the 24th of February, 1906, at Station 20. These machines having proved more satisfactory than the elevating grader, the work with graders was discontinued after January 1, 1907, the teams sold, and a third revolving excavator was purchased; these three machines being used exclusively after this date on all the work done by this company, being about 889,000 cubic yards. Shippey & Outzen used wheel scrapers and elevating graders, drawn by traction engines and served by eight four-horse dump wagons to each machine, on all the work performed by them, which amounted to 767,000 cubic yards. On account of the hill being so close to the river bank between Stations 196-222, the greater part of the material would have had to be handled twice with Armstrong excavators, and since the ground was too steep to use grading machines, a steam shovel was procured for this section of the work.

All of the graders used were what is termed "Standard Western Elevating Graders," with 21-foot elevator, using an extra heavy or giant railroad plow for loosening the material and throwing it on the elevator. This plow was attached to one side of the frame of grader. The only portion of the canal completely excavated to grade by these machines was from Stations 10-20 and 145-163, which proved unprofitable on account of the material usually becoming too hard near the bottom to be loosened by the plow, and the height to which the material had to be lifted in getting it to spoil banks too great. These machines, in connection with wheel scrapers, were most successfully used in making a cut from 8 to 12 feet in depth, and 110 to 120 in width, off the top. This left a strip about 30 feet wide inside the slope stakes on each side for the drag bucket excavators to work from in taking out the remainder of the section. This arrangement gave the elevating graders the soft material to which they were best adapted, and, at the same time, the least lift in conveying the material to spoil banks. This method was practiced between Stations 222-290, and accounts for the low cost of work done by these machines on this section.

The steam shovel outfit consisted of a 65-ton Marion shovel, one 25-ton and one 20-ton dinkey locomotive, and eight "Oliver" 12-yard, side dump cars, all standard gage; with about 1¼ miles of track, a tank, and pipe line and pump for supplying water to shovel and locomotives. The steam shovel outfit, working between

Stations 196-222, was profitably used in taking down the hillsides and removing the dry material from the top of the cut, but as the depth of the cut increased below the top of spoil banks, the two trains were unable to supply the shovel with empty cars fast enough to keep it busy, and, finally, after having made one cut through to grade, the bottom was found to be so soft that it was impracticable to work the shovel and it was removed to another part of the work and the Armstrong excavators were used to remove remaining 42,000 cubic yards.

The two Armstrong excavating machines consisted of a bottom wooden frame which rested on wooden rollers placed on skids, and on this frame was a spider about 20 feet in diameter, carrying sixteen dollies which revolved on a circular track made of 90-pound rail. This supported the heavy top frame which carried the machinery, boiler, tank, fuel, and derrick. The top frame is revolved by a single drum reversible engine, the wire line being carried from the drum by sheaves to the steel rail placed underneath the top frame; this rail serving as a bearing for the dollies, and also a drum for the swinging line, the ends of which were attached to it. The top and bottom frames were provided with central pin and socket castings which held the top frame and spider in place. A boom 81 feet long was attached to one end of the top frame and

Fig. 1. Drag-line bucket excavators on Colbert Shoals Canal

stood at an angle of 30 degrees from the ground. A double drum hoisting engine, 10 by 12 inches, was located a little back of the center of the frame, and the boiler and tanks were located well back to counterbalance the weight of the boom and bucket. The Page scraper bucket of 2 cubic yards capacity was used, rigged with a hoisting line from one drum of engine, passing over the end of boom, using two single blocks and attached to the back bail of bucket, with a loading line from the other drum passing through a sheave attached to the front bail of bucket, then brought back and attached to the top frame, under the boom. The McMyler machine was rigged the same as the Armstrong machines and was similarly constructed, except that the frames were of steel, mounted on trucks, and was revolved by a circular rack attached to the bottom frame and a pinion geared with hoisting engine, and used a 1½ cubic yard bucket. Where these machines were used the surface was usually stripped to a depth of from 4 to 12 feet by elevating graders and wheel scrapers, leaving a strip about 30 feet wide inside the slope stakes on each side for supporting the drag-bucket machines. This was done for the purpose of preventing the spoil banks from becoming too high for dumping. One Armstrong machine was usually kept in front taking the excavation to grade from the foot of the slope to center line, with the McMyler following trimming the slope, and the other machine following on the opposite side, removing the remainder. This arrangement is shown in the two illustrations.

The methods of excavation having been described, the following table shows the quantity handled and the comparative cost of each method. The cost, as given in these tables, includes labor, material, repairs, fuel, feed and care of live stock, and running expenses during delays occasioned by high water and bad weather, but makes no allowance for depreciation of plant or interest on money invested in plant.

Table of Quantities Handled and Cost by Each Method

Stations	Wheel scrapers		Graders		Excavators		Steam shovel		Total
	Quantity	Per cubic yard	Quantity	Per cubic yard	Quantity	Per cubic yard	Quantity	Per cubic yard	Number cubic yards
10-135	90,000	$.18	267,202	$.14	400,000	$.12			757,202
135-163	52,000	.22	221,674	.17	------	------	------	------	273,674
163-196	25,335	.24	255,150	.20	55,000	.30	------	------	335,485
196-222	------	------	------	------	42,240	.22	187,559	$.28	229,799
222-260	30,073	.20	102,000	.15	200,000	.11	------	------	332,073
260-290	10,000	.23	71,112	.16	192,027	.09	------	------	273,139
Total	207,408	------	917,138	------	889,267	------	187,559	------	2,201,372

Classification, Contract Prices, and Quantities for Each Contract

Classification	Contract price per cubic yard	No. cubic yards 10-110	No. cubic yards 110-210	No. cubic yards 210-260	No. cubic yards 260-290	Total
Earth	$.1749	507,377	638,381	399,370	------	1,545,128
Hardpan	.50	67,402	252,399	63,302	------	383,103
Unclassified	249	------	------	------	273,139	273,139
Rock	1 00	2	------	------	------	2
Total	------	574,781	890,780	462,672	273,139	2,201,372

The high cost of work done by the wheel scrapers, as given in the above tables, is caused by the scrapers being used to a great extent for serving the elevating graders in excavating and filling runways, ditching pits, and cleaning mud from in front of the traction engines after showers. Some of the expense above was charged to the graders, but as the scrapers and graders were worked together in the same pits it was impracticable to keep an accurate account of the work done by each. Therefore, if the work done by both methods was considered in one total cost, the result would be more accurate.

The high cost of work done by elevating graders between Stations 145-163, where the canal was excavated to grade by these machines, was caused by the large quantity of hardpan, the high lift and the long haul; and between 163-196, on account of the hard material. On this section the use of graders was abandoned when within about 5 feet of grade, because the material became so hard that it could not be handled profitably with these machines, and the drag-bucket excavator and steam shovel were used to finish it.

The high cost of material removed by the steam shovel as stated

in above tables, is attributed to the soft condition of the bottom of cut, and the height to which material had to be raised over a track which could not be kept to surface and alignment on account of the soft condition of the spoil banks.

The wheel scrapers, elevating graders and steam shovel having removed the cream of the excavation in most instances, the drag-bucket excavators were left the hard material which was mostly found near the bottom, besides being required to lift the material to a greater height. Another advantage of the drag-bucket excavators over the wheel scrapers, elevating graders and steam shovel, was their ability to work successfully in pits containing from 2 to 3 feet of water, and the fact that ordinary rains did not interfere with their output. It was also the only machine on which two and three shifts were worked profitably.

Fig. 2. Colbert Shoals Canal, June, 1908

Taking all the foregoing facts into consideration, it will be readily seen that the drag-bucket excavators were the most economical and satisfactory machines used in the excavation of Colbert Shoals Canal.

COMPARATIVE DAILY COST OF LABOR BY EACH METHOD

Drag-Bucket Excavators

Three enginemen, at $260 per month	$8.66
Three firemen, at $2 per day	6.00
Three laborers, at $1.50 per day	4.50
One master mechanic, at $125 per month	4.16
One pump man, at $1.50 per day	1.50
One blacksmith, at $3.00	3.00
One foreman, at $75 per month	2.50
One coal wagon with driver, at $2	2.00
Total	$32.32
Cost for each of three machines	$10.77

Elevating Graders

Two enginemen, at $80 ($160)	$5.33
Two firemen, at $1.75 per day	3.50
Sixteen teams (four-horse), at $2.50	40.00
One water wagon, with driver, $2	2.00
One pump man, at $1.50	1.50
One blacksmith, at $3 per day	3.00
One helper, at $1.50	1.50
One foreman, at $75 per month	2.50
Total	$59.33
Cost for each of two graders	$29.66

Wheel Scrapers

Fifteen wheel scrapers, at $2 per day	$30.00
Three snap teams, at $2.25 per day	6.75
Five laborers, at $1.75	8.75
One blacksmith, at $3 per day	3.00
One helper, at $1.50 per day	1.50
One foreman, at $75 per month	2.50
Total	$52.50
Cost for each scraper	$3.50

Steam Shovel

One foreman, at $125 per month	$4.16
One shovel engineer, at $125 per month	4.16
One crane man, at $90 per month	3.00
One shovel fireman, at $2 per day	2.00
One blacksmith, at $3 per day	3.00
One helper, at $1.50 per day	1.50
One pump man, at $1.50 per day	1.50
One coal wagon, at $2 per day	2.00
Two dinkey engineers, at $2.00 per day	4.00
Two firemen, at $1.50 per day	3.00
Two brakemen, at $1.50 per day	3.00
Sixteen laborers on dump, at $1.50 per day	24.00
Three laborers at shovel, at $1.50 per day	4.50
Total	$59.82

Only three laborers were required at shovel, as the shovel was idle part of the time on account of an insufficient number of cars being furnished.

ELEMENTS AFFECTING LOCK CONSTRUCTION ON CANALIZED RIVERS HAVING FIXED DAMS

BY

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Assistant Engineer

The location of locks for canalized rivers has not received sufficient attention in the writings of American engineers. So far as known to the writer, the discussion on Mr. R. C. McCalla's paper on "Improvement of the Black Warrior, Warrior, and Tombigbee Rivers in Alabama," published in the Transactions of the American Society of Civil Engineers, Volume XLIV, 1901, and chapter 1, part 3, of "The Improvement of Rivers," by B. F. Thomas and D. A. Watt, published in 1903, and occasional brief statements in the reports of the Chief of Engineers, U. S. Army, constitute the bulk of what has been written by American engineers on this subject.

During the years 1892 and 1896 locations were made for seventeen locks with fixed dams on the Cumberland River. At eight of these sites the locks have been built and seven have been placed in operation. Unless otherwise stated, this paper is a statement of the writer's individual experience and opinion gained on this work, and is intended to apply to such streams as the Cumberland River, and, by reason of its similar regimen, to the Tennessee above Chattanooga.

Experience has abundantly taught in Europe and America that the first essential in the location of locks on canalized rivers is that the elevations of the upper miter sill of the lower lock and the lower miter sill of the lock immediately above should be practically the same, and placed at a predetermined distance below the greatest draft to be provided for, and that the intervening pool should be assumed to be level, the slope of the canalized river being disregarded. A clearance of at least a foot should be found at the shallowest places in a pool over the navigable depth proposed. If the navigation is to be greatest at extreme low water, it

should be 2 feet. This may be said to be the only iron-clad rule for lock location.

The permissible lift of the dams and the slope of the bed of the river control the horizontal distances between the locks. Variation of the slope is found in all natural streams and is caused by bars with shallow water, intervening pools with deep water, and straight reaches, all with a constantly changing hydraulic radius. With a rocky bed the bars are practically fixed, and they consist of rock ledges which, as a general rule, are usually broken and badly eroded at the lower ends. The fall in these streams occurs at the bars. Pools between the bars are usually deep, with sand and gravel for the overlying material when any is found.

On the Cumberland River, and likewise on the Tennessee River above Chattanooga, the above are characteristic features, the exceptions being when the river widens out and islands, towheads, and a sinuous channel form bars which are not always fixed. Such islands and towheads have been formed by drift catching and accumulating until finally enough silt is caught to sustain vegetation. At some of these wide places the rock is found at relatively great depths for these streams.

One of the very noticeable features of the Cumberland River is the high limestone bluffs which occur first on one bank and then on the other. In no instance below Burnside, Ky., are rock bluffs found on both banks opposite one another. In the bends the bluffs are found on the concave bank or the "bend side," as the river men call it. In the bends the deepest water is generally found near the concave bank. During the ages of the flow of these streams, some of the softer ledges have been eroded more than the overlying harder ledges, leaving overhanging rock, locally known as "rock houses."

At numerous points on the Cumberland these rock houses are very noticeable, and at several places were very dangerous to steamboats and rafts, notably so at Whiteleys Rock and Sconces Rock. At the last place the rock house was removed by blasting many years ago. The danger to navigation at these points has disappeared since the building of Dams Nos. 5 and 6.

The winding course of these streams is very noticeable, and has evidently been brought about by erosion of the bluffs caused by high velocity of the water on the concave side and accretion on the convex or "point" side, caused by the lessened velocity on that side. The earth banks are usually high, averaging about 50 feet

above low water on the Cumberland, with slopes averaging about 1½ horizontal to 1 vertical. The bottom lands between the top of bank and high ground are similar to the bottoms on alluvial streams, high near the river, sloping back and then sloping up to the high ground. The banks are remarkably stable considering the steep slopes, and usually remain stable so long as the toe is left undisturbed. Changes in the regimen are of such rare occurrence that it may be truly said that these rivers have a fixed regimen.

The location of locks for canalized rivers depends so much upon the local conditions of the particular stream where such a change in condition is to effected that it is almost impossible to state definitely, other than the rule above given, what are the elements of good lock location for canalized rivers. Even on the same river what would be an eminently satisfactory site for a canalization with movable dams might be very unsuitable for a lock with a fixed dam, and a suitable site for a low lift dam might be unsuitable for a dam of much higher lift. An eminently suitable site on a river rarely if ever turbid might become a serious blunder in location were the river to become turbid, easily depositing the matter carried in suspension. The permissible lift of the dam, the slope of the bed of the stream, the height of the banks, and, for financial reasons, the extent of safe cultivation on the banks, are the controlling factors. The slope is generally not uniform, and in consequence it is impracticable to place the locks a uniform distance apart. The height of the banks and the extent of the safe cultivation of the same likewise vary on different streams within very wide limits, and also on the same stream in its different sections.

Under such a variety of conditions it would be impossible to attempt, even briefly, to outline the general subject within the space allowed.

The general arrangement of the lock and cross section of the dam, while not apparently involved in lock location, exert such a large influence on their operation and maintenance and ease and safety of navigation, that even at the risk of seeming to go beyond the limits of the subject some remarks seem necessary.

It is believed that the lock should be of solid design without culverts in the walls, or other openings, and have sufficient guard to permit safe navigation at all stages; that the devices for filling and emptying the chamber should be as simple as possible, and that the discharge of water in filling and emptying should be in directions to insure the scouring out of

sediment in the chamber and away from the lower approach. The method of filling under the upper miter sill and emptying through valves in the lower gates is believed to possess superior advantages to any other method. With the exception of chains for operating the filling valves, which can not be too strongly condemned, these appliances used on the Cumberland River locks have passed the experimental stage and can be fully relied upon to work properly. On new work cylindrical valves for filling are preferred. Locks with longitudinal culverts in the walls, with ports opening into the chamber near lock floor and discharging through culverts opening in the walls below the lower gates, will not be efficient in scouring out deposit. More masonry is required in their construction, and by reason of the culverts, ports, air holes, and wells for valves, lines of weakness will be introduced into the concrete masonry. It is much to be desired that all locks on one stream should be built after one general design. A standard lock, valves, gates, etc., for the western rivers is much wished for and would insure economy in construction and operation. An upper guard wall having a vertical face, with a drift gap at upper end of the lock, is a necessity, and experience with those on the Cumberland indicates that the wall should be solid. No lock can be considered finished without guide walls having vertical faces and with heights equal to the walls of the lock, and of such length as is required by existing navigation. The gates, valves, operating machinery, etc., should be of sturdy design and preferably copies of existing satisfactory types, a lock with its equipment not being the place for experiment.

After a lock and dam is located, constructed, and put into operation, one of the first things to give concern is found in the condition of the water immediately below the dam. At low and fairly low medium stages there is found no trouble, but as the river rises the phenomena change and there occur waves accompanied by back lash, reaction of the water, eddies and erratic currents, all changing with the stage of water and varying with the lift of the dam, affecting navigation and, during certain stages, endangering the stability of the dam by drift caught below and thrown with violence against the dam. Also, at epoch of submergence, the waves prevent safe passage up over the dam. Take, for instance, the dam at Lock A, which at low water with the open river below has a lift of 18.25 feet, is 535 feet long on the crest, 22 feet 2 inches high above the bottom and 50 feet wide, and is

built of timber cribs filled with stone and placed in a fairly straight reach. As originally built the dam had a vertical face 19 feet 5 inches high, then a rising slope of 1 in 3.63 for 10 feet to the crest, then a falling slope of 1 in 2.71 for 30 feet 2 inches, then a vertical drop of 2 feet 8¾ inches, then a 10-foot horizontal apron, and then the vertical lower face 8 feet 4 inches high. The dam was built during the low water season of 1904. On February 10, 1905, with 8.6 feet of water on the crest of the dam, there was a fall over the dam of 8 feet. The drift running in the river began to accumulate in the reaction or back lash below the dam, where it was held until February 17, when with a fall of 9.2 feet over the dam the drift disappeared. On March 10, 1905, with 9.5 feet of water on the crest and a fall of 7.5 feet over the dam, the drift again began to accumulate and was held until March 17, when the fall was 6.5 feet. During these two periods the drift caught and held in this reaction or back lash inflicted serious injury to the roof of the dam on the lower slope. When the water fell sufficiently to see the extent of the injury, it was found that the lower half of the lower slope had been destroyed in places and large holes made in the dam filling. During the months of October and November, 1905, the damaged parts were repaired by filling the holes in the damaged places with concrete and double drift-bolting the lower ends of the timbers on the lower slope and apron, but still retaining the original section.

During the winters of 1905-1908, whenever the same stage of water occurred as given above, the same phenomena occurred with resulting damage to the dam. It became evident that more radical repairs were required. After a good deal of discussion it was decided, in 1907, to make repairs on a more extensive scale, covering the dam with concrete 3½ to 4½ feet thick, changing the lower slope to 1 in 4 and extending it to the lower face of the dam. The work was undertaken with many misgivings as to time required and cost of work. However, it was found comparatively easy, rapid, and inexpensive. During the low water season of 1907 the water was too high and the work could not be done. A favorable stage of water enabled the work to be done during the fall of 1908. The lower slope of the dam was replaced with concrete entirely across the river, 3,757 cubic yards being laid at a cost of $4.65 per cubic yard. After this change was made in the section of the dam, the disturbances below the dam became very much less violent at all stages, and little if any drift has been held in the reaction. So far

as can be known without taking the water off the slope, no damage has been done to the dam. In the case of the other dams with lifts of 6.5 to 12 feet on the Cumberland having lower slopes of 1 on 4, no trouble has been experienced with drift held in the reaction below the dam, and the disturbances below have been very materially less than at Lock A either before or after it was repaired.

From the foregoing it is seen that the rule given by Colonel Mackenzie on June 12, 1903, ''The section should have a slope of about one-fourth, with an upstream slope of about 10 feet wide above the comb and a downstream apron of about 10 feet wide,'' is founded on good and sufficient reasons. Search has been made for the origin of this rule, but without success.

No one subject in the whole of canalization with locks and fixed dams is so little understood as the effect which will be produced by the overfall from the dam, and the necessary guard to be given the lock in order that when the locks become no longer available for the passage of boats, the boats may pass up over the dam with safety. Owing to the waves below a dam, our present knowledge is not sufficient to determine at what stage safe passage may be made over a dam. With boats having overhanging guards, the use of a lock when the water is high enough to permit the guards to overhang the top of the lock walls becomes so dangerous, both to the boat and to the lock, that a freeboard to the lock walls of something like 3 feet should be provided in order to eliminate this danger. Boats having excessive freeboard are clumsy and hard to handle and should not be allowed to use a lock. One or two instances have occurred here where there was imminent danger from this source. A practical solution of this trouble is to build lock walls to the height at which navigation in the open river becomes unprofitable by reason of the drowning out of landings or increase in the current. This would entail additional cost and in some instances might give a greater guard than needed. Two known exceptions on the Cumberland are easily explained. Lock No. 1 has a lift of 6.5 feet, a guard of 15 feet, and a dam 439 feet long. When there is 6 feet on the dam and a fall of not more than 8 feet, boats go up over the dam. This lock was designed and built for a lift of 9 feet, but the construction of Lock A raised the pool below and decreased the lift as given above. The low lift at this dam, together with the long pool below, is a satisfactory explanation for the condition obtained. At Lock No. 5 the lock has a guard of 12 feet, a lift of 12 feet, and a dam 505 feet long. When there

is 11.7 feet on the dam, boats can go over the dam. The river here is wide for some distance above and below the lock, and this, together with the long dam and long pool below, satisfactorily explains the condition found at Lock No. 5, which, if it had walls 3 feet higher, would comply with the requirements of being able to permit navigation at all stages.

Some contend that by placing the lock and abutment well back into the bank, the increased length thus given to the dam would be efficient in reducing the fall, but such is believed to have no foundation in fact. On the Monongahela River, Lock No. 7, built in 1883, has a lift of 9.2 feet, a guard of 9.2 feet, and a dam of 525.5 feet long. Lock No. 6. 14.07 miles below Lock No. 7, has a lift of 13.3 feet, a guard of 9.6 feet, and a dam 626 feet long. Lock No. 8, 5.75 miles above Lock No. 7, has a lift of 10.6 feet, a guard of 10.2 feet, and a dam 600 feet long. At Lock No. 7 ''the walls are submerged about 3 feet and the lock is incapacitated for use while the locks next above and below may still show out of the water. * * * It was thought at one time that by remodeling the abutment of Lock No. 7 and slightly lengthening the dam some improvement would result; but no material benefit was derived from the work which was done.'' Extract from a paper on ''The Monongahela River,'' by Col. T. P. Roberts, U. S. Assistant Engineer, in Proceedings of the Engineers Society of Western Pennsylvania, May, 1908, page 310. It is believed that systematic observations should be made in a uniform manner on all canalized rivers having locks with fixed dams. Compilation and study of such observation might lead to a satisfactory solution of this problem.

Vernon Harcourt says in ''Rivers and Canals,'' page 40, edition of 1882, ''The lock is usually placed where a river is divided into two channels with an island between, the lock being situated in one channel, and a weir keeping up the water to the level necessary for navigation across the other channel. If no natural division of the river occurs at a point sufficiently close to the place where a change of water level is desirable, a site is selected where the river makes a sharp bend, a new straight channel is excavated across the bend and the lock is constructed in the channel. The ordinary discharge of the river follows the old channel and flows over the weir placed in bend. This latter arrangement, though necessitating more excavation, is preferable, as it interferes less with the original channel.''

Judging by examples of lock location as found in various English and Continental publications, such locations as above described

seem to be the ones preferred. The island location, or what is practically the same thing, a lateral canal, may be the proper one in the case of rivers carrying little or no silt and where the lock walls are never submerged. But on our silt-bearing western rivers, such locations can not be too strongly condemned. The following quotations show what may be expected on these rivers under consideration on such locations.

The late Col. Wm. E. Merrill, Engineer Corps, U. S. A., in a published report in the report of Chief of Engineers, 1888, page 1703, says: "The greatest obstruction to successful navigation on the Muskingum is caused by the lateral canal. They are expensive to keep up on account of the guard gates, the numerous drawbridges, and the necessity of periodical dredging. Even when in perfect condition they must be navigated slowly, and it is with difficulty that boats can pass each other. There are five lateral canals on this river, of which four must undoubtedly be retained; but the fifth, that at Taylorsville which is the longest, the most difficult and expensive to keep open, and the most liable to damage in time of flood, is wholly unnecessary, and can be abandoned by the simple expedient of building a lock at one end of the dam. The cost of maintaining a little more than a mile of useless canal would thus be saved, and the time required for passing would be appreciably reduced, while the cost of repairing flood damages would be wholly obviated." (The river has thrice carried away the canal banks and necessitated heavy expenditures for reconstruction.)

The following remarks of Mr. M. Meigs, United States Civil Engineer, member American Society of Civil Engineers, in Transactions of the American Society of Civil Engineers, Vol. L, 1903, page 185: "The writer has had twenty years experience on a canal 7½ miles long and from 250 to 350 feet wide, on the Mississippi River at Keokuk, Iowa. This canal receives the, at times, muddy water of the river necessary to feed it and to provide for lockage; and, in addition, two small creeks and a few short water courses empty directly into the canal. The rainfall in this latitude is only 40 inches as against 200 inches, or thereabouts, on the Isthmus, and yet it requires the almost constant attention of a dredge to keep the channel open for navigation. In the twenty years of the writer's connection with the canal 1,600,000 cubic yards of mud, sand, and gravel have been removed from the canal prism in a length of not more than 5 miles; two deep pools at the lower ends of reaches of the canal not yet having shoaled sufficiently to require

dredging, and aggregating about 2 miles in 7½ miles of canal. On several occasions a single storm, lasting not twenty-four hours, has thrown enough material into the canal to keep a large Osgood dredge at work for a month removing it, working night and day sixteen out of the twenty-four hours.'' When taken with the remarks of Colonel Merrill, this is believed to dispose of such a location.

With the bend location (convex bank), the same troubles will be found as with the island location. In addition there are two more very serious objections, one being the difficulty and danger in entering the lock going downstream, and the other being deposits at the lower entrance to the lock when the lock is submerged. Both objections are found at Lock No. 2, Cumberland River, which is located on the point side of the bend. The fear of drift running into a lock placed on the concave bank no doubt has had much influence in placing locks on the convex bank, but experience on the Cumberland indicates that drift is carried into a lock entrance only when the wind sets across the current toward the lock.

An ideal site for a lock with a fixed dam on a stream with conditions similar to those found on the Cumberland River should have the following characteristics: *First*, Solid rock lying fairly level at an elevation about 2 feet below the lower miter sill of the proposed lock and 2 feet below the upper miter sill of the lock next below, with no higher bottom in the channel in the intervening pool, the rock to extend entirely across the river and for a distance of about 2,500 feet. The lock would be placed about 300 feet downstream from the upper limits of the solid rock. *Second*. The river with its width increased from 100 to 250 feet beyond the average width of the river where the lock is located, and such increased width extending at least half a mile above and the same distance below, practically straight with parallel banks. *Third*. High banks with a rock bluff on one side extending ½ mile below the lower end of the lock, and a firm bank on the other side where the lock would be located with no depressions between the top of the bank and adjoining high ground. *Fourth*. No large tributaries discharging into the river within half a mile, either above or below the lock. *Fifth*. The presence in sufficient quantity, within easy boating distance, of available sand and gravel deposits and stone suitable for dam filling and paving. *Sixth*. No important public landing nearer than ½ mile below the lock. *Seventh*. Springs of potable water well above low water in the river.

It is not expected that any such ideal location can be found. A rock foundation is so desirable that it is apparent without calling attention to it, and it should be the desiderata first sought for. A level rock foundation with its level not higher than that given will insure more rapid and satisfactory construction of the masonry than rock at a higher elevation which has to be removed by small blasts, gads and crowbars, such work being tedious and expensive. Experience on the Cumberland River indicates that it is decidedly better practice, both from a construction and money standpoint, to found on a lower lying rock than to make rock excavation for the lock. Should one have to decide between placing the lock or abutment on rock, it is believed that the lock should be placed on rock, as thereby a saving would be likely to occur in first cost and would be sure to prove very much more economical in maintenance. The presence of solid rock below the dam will prevent the scouring out of the bottom.

In order to get the benefit of increasing the length of a dam, it is essential that the width of the river be increased beyond its normal width above and below the dam for an appreciable distance. Increasing the width for a short distance above and below the dam by excavation into the banks would entail a prohibitive expenditure and afford no material aid to navigation.

All cutting into banks should be reduced to a minimum, it having been observed that river banks of rather treacherous material remain fairly stable so long as the toe of the bank remains undisturbed. The toe of banks, if protected prior to the construction of the dam, generally insures the banks against heavy caving. In the unimproved river a serious caving of the bank has been observed when a sand digger removed sixty yards of material from the toe of the bank, and the caving continued for several years. It has been observed that the destruction of the banks is more on the abutment side than on the lock side. A rock bank or bluff at and below the abutment for ½ mile is an extremely desirable feature, as thereby the cost of the abutment and bank protection would be saved.

Careful observation and study of rock in the exposed bluffs along the river, and elsewhere in the vicinity, will be time well spent; for it will afford some indication of what may be found in the bed of the stream. An experienced field geologist familiar with the locality should always be employed in connection with the party making explorations for the site. Such a man would have known that black shale was to be looked for at the site of Lock No. 21.

The examination of the sites can be made more satisfactorily at low water, and if the underlying rock is not at greater depths than can be reached with steel 26′ long, the most rapid and satisfactory method for getting the underlying rock surface is by driving steel rods through the overlying soil, sand, and gravel to rock. An experienced quarryman can usually tell by the ring of the steel whether the rock is solid or not. The steel used should be purchased in long lengths, as it has been found impossible to get satisfactory results from bars welded into long lengths, the welded bars breaking under the blows of the hammers required to drive them. Such borings or probings are quickly and easily made, and can be multiplied sufficiently to completely cover a site and show the surface of the underlying rock.

Where possible to be used, the above method gives satisfactory results at a minimum cost, and every crevice can be traced out. When the underlying rock lies too deep to be reached by the steel rods, wash borings have to be made; and, owing to the longer time required for each boring, the progress of the work becomes much slower with an increased cost. As a rough estimate, wash borings will cost from three to four times as much as the steel rod method, and consume time even in a greater proportion.

In order to determine the kind and texture of the underlying rock, a core drill should be used with both methods and cores taken out to depths of, say, 5 to 20 feet, depending upon the rock and relative importance of the structure proposed. The cores should be saved and submitted to the field geologist for examination.

The site for a lock and dam of ordinary lift does not require as careful and extensive exploration as is necessary in the case of a dam with a relatively great lift which is to be built of masonry. No money is ever spent to greater advantage in lock and dam construction than that spent in exploring the site, and it can not be too strongly urged to make the exploration very, very thorough, giving ample time for the work. It is safe to say that for every dollar wasted in making too thorough exploration of sites, hundreds have been lost in construction as the result of having done such work in a hurry and superficially.

DISCUSSION

Mr. JNO. S. BUTLER

Junior Engineer

As this excellent paper deals especially with the broader and more general questions relating to the location and design of locks with fixed dams, it may be of additional interest to discuss in detail some of the elements entering into this subject, and to point out their effect on the work of construction.

Concerning the fixed regimen of the streams, the following statement is found in this paper:

> "The banks are remarkably stable considering the steep slopes, and usually remain stable so long as the toe is left undisturbed."

An experience of several years on the Cumberland River enables the writer to add favorable testimony in support of this statement as far as it applies to that stream.

In the extreme upper portion of the navigable river, however, it appears that the banks are not so stable as those found lower down. The earth contains a large percentage of very fine sand, and is very porous, and when saturated with water has a very small angle of repose. When the toe is disturbed, or when the top soil above the toe is removed, containing as it does roots of trees and grass, the stability of the bank is very much reduced, and it is a question of only a very short time until a slide occurs. These slides are not uncommon on the upper portion of the river, even when it is not apparent that the toe has been disturbed. They generally occur after a period of high water and are sometimes of considerable extent.

During the construction of Lock No. 21, the contractors indiscriminately cut trees and grubbed up or dynamited stumps along the banks, causing many slides. These slides delayed the work and added materially to its cost. One well remembered slide carried more than 1,000 cubic yards of earth into the lock pit.

Experience teaches that the excavation for walls in banks of this character should not be started until everything is in readiness to build the wall without delay.

In regard to the lock walls and the method of filling the lock, Mr. Walker says

> "It is believed that the lock should be of solid design without culverts in the walls or other openings. * * * The method of filling under the upper miter sill and emptying through valves in the lower gates is believed to possess superior advantages to any other method."

The solid wall has without doubt the advantage of simplicity; but, since the introduction of concrete masonry in lock construction there seems to be a growing tendency toward cutting up the sections

of the lock walls with culverts and other openings. For large locks this practice may be justified when the resulting benefits are of sufficient importance. By using circular openings, rounded corners, and if need be, steel reinforcement in vital places, these lines of weakness may be strengthened.

As the advantages of filling the lock under the upper miter sill and emptying through valves in the lower gates have been fully stated, it may not be out of place to mention here some of the disadvantages of this method.

a. Increased danger to navigation on account of the resulting water currents inside and below the lock.

b. Increased danger to the lock men on account of the necessity of operating the emptying valve levers from the top of the lower gates. (There are ten of these valve levers on the Cumberland River gates, and they are at times difficult to handle. The gates are narrow and the danger is very much greater in wet and freezing weather.)

c. Complications in design and construction of the lower gates, on account of the presence of the emptying valves.

Further on it is said:

> ''An upper guard wall having a vertical face, with a drift gap at the upper end of the lock, is a necessity, and experience had with those on the Cumberland indicates that the wall should be solid.''

In this connection it may be interesting to see what another authority has to say on this subject.

Col. Wm. L. Sibert, in his discussion of Mr. McCalla's paper on the Improvement of Rivers, which has been referred to in the paper under discussion, says:

> ''The guard wall should be solid, with possibly a short drift gap next to the head of the river lock wall. * * * The solid wall will deaden the water in the entrance so that barges can be taken into the lock by hand. * * * A guard wall made entirely of clusters of piles from 30 to 70 feet apart, makes the entrance to the lock very difficult and dangerous. When the water is high, the draft of the water between the pile clusters pulls everything hard against the clusters, making it impracticable to place barges into the lock by hand. The forward outside corner of a barge is likely to be drawn in behind a cluster and a steamboat would be forced to put out a line to get the barge out.''

Colonel Sibert's criticism, as stated above, does not seem to apply to the type of concrete guard wall used on the Cumberland, although this is not a solid wall. This wall is composed of seven concrete piers 10 feet long and 14 feet wide at the base, spaced 12 feet apart in the clear. These piers are joined on their face with a reinforced concrete curtain wall 3 feet thick. This curtain wall extends from 1 foot below the normal pool level to the elevation of the top of the lock wall, thus presenting to boats entering the lock a face

which for all practical purposes is solid for the entire length of the wall. The draw under this curtain wall is not likely to be so great as to endanger navigation.

By making some minor changes in the plan, and by the use of a small amount of additional reinforcement, any objections on account of contraction cracks can doubtless be overcome.

Mr. Walker's observations concerning the fall over the dam and the resulting phenomena are exceedingly interesting and instructive. It is hoped that further investigation may lead, as he says, "to a satisfactory solution of this problem."

In regard to the location of the abutment and the fall over the dam, we find this statement:

> "Some contend that by placing the lock and abutment well back into the bank, the increased length thus given the dam would be efficient in reducing the fall, but such is believed to have no foundation in fact."

It would, doubtless, be very objectionable to place either the lock or the abutment far back into the bank. The bays thus formed would cause scour and cross currents, and it is probable that any reduction in the fall over the dam, on account of this increase in length, would be only local in its effect. However, the following example from the Monongahela River, given by Mr. Walker, does not warrant, in the writer's opinion, such a summary dismissal of this subject.

Distances.	Lock.	Lift.	Guard.	Length of dam.
Miles.				*Feet.*
0.00	No. 6	13.3	9.6	626.0
14.07	No. 7	9.2	9.2	525.5
19.82	No. 8	10.2	10.2	600.0

Concerning this, it is said:

> "At Lock No. 7 the walls are submerged about 3 feet and the lock is incapacitated for use, while the locks next above and below may still show out of the water. * * * It was thought at one time that by remodeling the abutment of Lock No. 7 and slightly lengthening the dam, some improvement would result; but no material benefit was derived from the work which was done."

In the case of Lock No. 7 it will be noticed that while the lift is less than for either Lock No. 6 or Lock No. 8, the guard also is less; and the length of the dam—which governs the fall, other things being equal—is very much less, being 100.5 feet less than at Lock No. 6 and 74.5 feet less than at Lock No. 8.

At Lock No. 6 the available area for discharge, when the lock walls are just on the point of being submerged is: 9.6 feet multiplied by 626 feet, or 6,009.6 square feet. At Lock No. 8 this area

is: 10.2 multiplied by 600, or 6,120 square feet. The average for the two is 6,064.8 square feet.

To give similar conditions for submergence at Lock No. 7, other things being equal, the guard should be 6,064.8 divided by 525.5 feet, or 11.54 feet. As the guard at Lock No. 7 is only 9.2 feet, a submergence of the walls of 11.54 feet minus 9.2 feet, or 2.34 feet, is to be expected at that place.

In view of these conditions it is hardly to be expected that any material benefit would result from slightly lengthening the dam at Lock No. 7.

A few years ago the writer recommended that the dam at Lock No. 21, Cumberland River, be increased 20 feet in length by moving the lock a corresponding distance toward the bank, and there were good and sufficient reasons for so doing. The quantities affected by this change produced no additional cost at contract prices, and material badly needed for embankment was made available. Some fall over the dam at the time of submergence of the lock walls was expected, and as well established hydraulic formulæ indicated that "the fall for high stages varies inversely as the length of the dam for the same discharge," it was believed that lengthening the dam in this way would have some effect in reducing this fall.

For the interest of those who are employed on regulation work, the lock with its closed gates may be compared to a work of contraction in the stream. The contraction produced by the lock would raise the surface of the stream above, and also increase the slope or fall. Should the length of the dam be increased by moving the lock toward the bank the tendency would be to reduce the elevation of the water surface above, and also to reduce the fall.

Mr. Walker says: "An experienced field geologist familiar with the locality should be employed in connection with the party making the exploration for the site. Such a man would have known that black shale was to be looked for at the site of Lock No. 21."

The black shale at Lock No. 21 occurs above the extreme low water surface near the site of the dam, and also in the island chute just above the lock site. The services of an experienced field geologist would without doubt have been useful in calling special attention to this geological formation.

The presence of this shale in the foundations at Lock No. 21 necessitated the following additions to the plans:

1. A concrete floor over the lock chamber averaging about 15 inches in thickness.
2. An apron or footing 8 feet wide and about 2 feet in thickness on the outside of the river wall of the lock.
3. An apron below the concrete dam, 20 feet wide and about 3 feet thick.

This shale seems to be entirely suitable for a stable foundation when not exposed to the action of the weather and when not subject to the scouring effect of strong currents.

Mr. Thos. P. Roberts
Assistant Engineer

Readers of Mr. Walker's paper can not help being impressed with the fact that the improvements of navigation on the country's inland waterways are far advanced on some of the most important rivers, which when connected with the arterial streams remaining to be improved, will form a network of avenues for reciprocal traffic between many wealthy and populous states abounding with mineral wealth and rich in agricultural resources.

Mr. Walker was not directing his attention, however, so much to the commercial prospects as to coming needs looking toward uniformity in administration, methods of operation of locks and dams, etc. Strict conformity, however, as to lock sizes, sill depths, lift of dams, guard height of lock wall, etc., is not to be expected in the case of streams having greatly different flood ranges, velocities, and discharges. So also bed slopes, height of banks, troubles from drift and ice, may call for special treatment as circumstances may require in determining location of locks. It certainly is time however, to consider the adaptability of improvements now in progress on all tributary streams, to accommodate a tide of traffic which will be developed upon them, when the markets of the entire Mississippi Valley are placed within commercial reach of each other. The erroneous notion that localities are interested only in what is below them, as the river flows, is an idea inherited from the days of the old wood choppers and raftsmen. On the Volga, in Russia, much the greater traffic is upstream. So, also, is upstream traffic large on the Rhine, and in recent years some of the Ohio packets, when they can be operated, find their most profitable business upstream. Tennessee, for instance, does little business now with Pennsylvania, solely because of excessive costs of transportation between them, and not because there are no advantages to be gained by an interchange of traffic.

It may seem somewhat curious that Mr. Walker in the opening of his paper dwells on the importance of choosing lock sites, where there is a series of them to be located, so that the full depth on the upper lock sill below will extend to that of the lower lock sill above, by this meaning to depend as little as possible on deepening any part of the channel between locks by dredging. There is sometimes considerable temptation to resort to deepening the heads of pools in this way in order to reach a good foundation for the upper lock or for some other "engineering reason," yet in silt-bearing streams this might be a bad thing to do, as frequent dredging may be required to maintain such a channel. The bed slopes of large rivers of so called "fixed regimen" should be regarded as almost inviolable, and accordingly preference should generally be given to lock sites down the pools, rather than up, from the theoretical point to reach a favorable location.

The regimen of a stream with large maximum discharge is not seriously disturbed by dams not intercepting more than four-tenths

the normal flood section, excepting for a moderate distance below the dams. Alterations in the shape of the shore lines, projecting abutments, and bridge piers, are more competent to change the channels, create bars, etc., than equal areas of obstructions laid down systematically across the river in the form of dams. This opinion is presaged on the fact that dams create only local horizontal disturbances along the axis of the streams which are soon lost, whereas obstructions creating transverse deflections may extend from shore to shore, developing secondary and tertiary effects, sometimes worse than the original cause and quite remote from it.

The writer agrees with Mr. Walker in recommending wickets in lock gates for filling and emptying locks up to the limit where their capacity is sufficient with, say, 8-foot lifts, to do the work either of filling or emptying the chambers in not to exceed six minutes. It would not be advisable for several reasons to make wickets in gates large enough to fill locks the size of those on the Lower Monongahela, viz: 360 by 56 foot area, in the time specified. On the Monongahela wickets in the gates are retained, but the filling and emptying of locks is usually done by means of conduits with either cylindrical or butterfly valves placed in the walls. Four minutes' time for 8-foot lift is required. The filling is done from conduits extending down about 80 feet below the upper gates, having ten orifices, or five in each wall. The movement of steamer wheels appears to keep the lock floors clear of obstructions. The walls are not increased in section where they have conduits in them so that their use on the Monongahela, and also as proposed for the Panama, as well as on other locks, reduces the amount of concrete in construction, but not the cost, when forms are taken into account. Between the chamber faces and the conduits the intervening concrete, on Monongahela River locks, is 3 feet thick, and considered as columns the load on the wall between conduit opening is, in the maximum case, not quite 4 tons per square foot. There is no indication of structural weakness in the walls, although upon unstable foundations lines of weakness, referred to by Mr. Walker, might develop.

Also, in the case of cast-iron cylindrical valves, referred to by Mr. Walker, the writer agrees with him in recommending their merits to the consideration of engineers. They are reliable and durable,provided due attention is paid to their setting in such manner that vibrations will be reduced to a minimum. Quite recently, after several years' constant day and night service with no repairs necessary, several cylindrical valves of 8-foot diameter broke down almost simultaneously at Lock No. 3 on the Monongahela. On one ring having 38 screw-bolts 32 were loose or broken off, the standards in every case broken, etc. There was no escape from the conclusion that the trouble was due to vibration which, perhaps, were imperceptible at first. By a misunderstanding of the plan it so happened that the standards had only half the metal in them that was called for. This mistake, however, is scarcely sufficient to account for the breakage.

Regarding reaction below dams during freshets, as affected by their form or section, much might be said. At Dam No. 1, on the Monongahela River, which is being rebuilt with a concrete top, with horizontal apron below, work ceased last fall with 490 feet of new work completed, leaving 460 feet of the old timber structure (built in 1840) with lower slope with 1 foot vertical to 4 feet horizontal untouched. Soundings were taken for several hundred yards below both sections, and during the winter to date a number of photographs illustrating wave action at different stages in the river have been made. Until the work of duplicating the soundings to note difference in scour, if any, has been done, no opinions will be ventured.

Experience on the Monongahela on the whole favors the location of locks on the concave in preference to the convex side of rivers. In the case of old Lock No. 3, on a slightly concave shore (now built on a different site) to avoid trouble with ice, a deflecting dike 600 yards above was built which remedied the difficulty very effectively. As very high floods submerge the locks on the Monongahela River from 10 to 16 feet, their location appears not to disturb the general trend of the currents. It would be a difficult proposition, perhaps, if the lock walls came up even approximately to high flood elevation. Immense deposits would be made below them, even if they were on the bend side of the river. As no two floods have the same slopes, or velocities, at corresponding depths, these varying factors result occasionally in unexpected and curious effects along the river which are difficult to explain, leaving always something to learn from "further observation." At least, the writer after almost three decades' observations of the rivers about Pittsburg, is still noting "unprecedented happenings." As Tennyson said (in part) "Men may come and men may go," but for the rivers "We go on forever," upsetting the finest wrought theories of engineers.

Mr. D. M. Andrews

Assistant Engineer

The writer believes that the location of locks, particularly on torrential streams, such as is the Cumberland River, should, first of all, be considered from the economic side, as is done in the investigation of any other great industrial enterprise.

Both the economic lift and economic navigable depth can be approximately determined, as indicated in the writer's paper: "The Economic Improvement of the Coosa and Alabama Rivers, in Georgia and Alabama," published in Vol. L, Transactions, American Society of Civil Engineers, 1903.

The economic lift affects the ultimate cost of the project; the economic depth, its success as a commercial enterprise.

The development of power should, under present industrial conditions, be considered in the location of locks and dams on navigable streams, and those locations which best conserve the interests

of navigation and the present or future needs of the people for power are the ones that should be chosen.

In a system of improvement on a torrential stream consisting of a series of locks and dams, the crest of each dam should be so placed as to give the minimum navigable depth on the lower miter sill of the lock next above without resort to much channel excavation, for the cost of subaqueous rock excavation will soon outrun the cost of the additional height of lock and dam required to overcome it.

The writer has had experience with filling and emptying through wall culverts, and emptying through valves in the lower gates, and advocates wall culverts extending the entire length of the lock, and filling through submerged openings located at equidistant points along the chamber walls, and culverts emptying into the tail bay, for the following reasons: The filling is accomplished with less disturbance than by other methods, and the accumulation of silt above the lower gates is prevented. In silt-bearing rivers, silt is deposited against the lower gates where the emptying is done through valves in the gates, and the writer has encountered trouble from silt with this type of fitting; on the other hand, where the bottom of the intakes of emptying culverts were placed 2 feet below the bottom of gates, no trouble from this cause was experienced.

The writer believes that the balanced, or butterfly, type of valve is best for locks under 20-foot lift, where loss from leakage need not be considered, on account of simplicity of construction and ease of operation.

Gate maneuvering gear, especially in the South where there is navigation the year round, should always be placed above water.

The writer has experienced the trouble from backlash at dams with stepped lower slopes, described by Mr. Walker, and overcame the trouble as Mr. Walker did, by the substitution of a long downstream slope. The method the writer employed is fully described in his paper on foundations, PROFESSIONAL MEMOIRS, Vol I, No. 4.

In fixing the guard for the proposed locks on the Coosa River, the overfall at each dam was computed for what may be called the extreme ordinary discharge, and the top of each lock so placed as to be at the point of submergence when that discharge is reached. The guards so determined were in no case excessive.

Locks are now of standard design, which probably can not be improved upon. The writer, however, can not agree with Mr. Walker that the equipment "is no place for experiment." In the absence of an experiment station for trying out new designs, a strict adherence to standards precludes all hope for improved equipment.

Short canals should never be employed as part of a system of improvement on the silt-bearing rivers of the South and West; for, as shown by Mr. Walker, the excessive silting is too great a charge against maintenance.

Where rock is sought for foundation, the writer believes that no test should be relied on, other than the core-drill test; for he is at present confronted with the problem of founding a lock on bad

foundation tested with the steel drill and pronounced ''good foundation.''

An inspection of the ''country rock'' is part of the foundation test. Limestone should be regarded with suspicion, and chert rejected. Chert, when in situ, represents a replacement of limestone with silica, and is almost sure to be faulty. If, however, it is the only available foundation, it should be tested with more than usual care.

Mr. THOMAS E. JEFFRIES

Assistant Engineer

Experience on the Kanawha River with fixed dams is limited to two locations. I do not not feel that I am in position to add much to what Mr. Walker has said on the subject.

I am of the opinion that the scour below fixed dams at times is underestimated, and even when a rock foundation is available the lower side of the dam should, if possible, be protected.

I have for some years advocated a slight batter on the chamber side of lock walls as a protection against damage from bolt-heads and iron bands on boats, particularly coal barges. Lock walls on this river with vertical chamber faces are badly worn and scarred, while others with battered faces, though of greater age, look nearly as good as when first built. I am aware that this is objected to by the profession as a rule, because it is thought boats may get jammed by being lowered in locking from a wider to a narrower width. But why could not the upper entrance be choked so that any boat that came in on the upper pool could get out one the lower one? Experience on this river with battered walls has been good, and though there were two boats jammed in a lock when the first ones were put in operation, it has never occurred since, and what else could you expect when an attempt was made to take two barges 25 feet wide through a lock 50 feet wide?

In drilling for rock, good results can be had by using a burley churn drill inside of a 3-inch gas pipe. The gas pipe will follow the drill to the rock and a very good idea of the quality of the rock can be formed from the drillings pumped out with a cheaply constructed sand pump. The sand pump can be made by crimping the edges of one end of a piece of gas pipe and a large marble used for a valve. While it may be a little more expensive to get up a rig for this kind of a drill the results are much better than a steel rod, and it can be used where a core drill is not available. For deep drilling a portable scaffold should be provided for the top drill man and a lever and chain for pulling the gas pipe casing. A drill of this kind was put to bed rock at Dam No. 11, 43 feet below low water.

The upper valves used in the locks with stationary dams on the Kanawha are placed horizontally in the upper bay, the water passing through culverts located under the miter sill. These valves work satisfactorily, but they do not wash the sediment from the lock

chamber, where it accumulates to an extent that requires dredging every few years.

The river banks below both of the stationary dams have been badly washed for lack of early protection. At one site it is worse below the lock, and at the other below the abutment.

Mr. W. H. McAlpine

Assistant Engineer

I have a few remarks to make on the very interesting paper by Mr. Walker on "Elements Affecting Lock Construction on Canalized Rivers Having Fixed Dams," basing these remarks on the experience I have had in operating and care of the Kentucky River, Kentucky.

Under "valves" I may mention that the cylindrical valves for filling valves have proved satisfactory on the Kentucky River, where they have been in use several years. They are easy to operate, and so far have required practically no repairs, and the mechanism shows no signs of wear.

At Lock No. 9, Kentucky River, Kentucky, with an 18-foot lift, a large single cylindrical valve in each wall is used for both filling and emptying the lock, and its use for both purposes has been entirely satisfactory. Both upper and lower valves discharge through cross culverts above the sill, and thence through ports or horizontal culverts under the sill. No more trouble has been experienced with deposit in the lock chamber and approaches than at other locks with valves in the gates.

At Locks Nos. 8, 10, 11, and 12, having an 18-foot lift, the locks are emptied by so-called "balanced valves" in the lower gates. These valves vary in size and design, some having a vertical and others a horizontal axis, but none have given satisfaction. They are hard to operate, easily get out of order, are liable to damage from drift, and are very difficult to repair, requiring unwatering with a batten at one opening and a "dry dock" at the other. Almost all of these valves which have been operated for several years have required repairs. I have yet to see a balanced valve of considerable size that operated easily under a head of 14 feet or more. Most of these valves require two stout men to operate them.

The cylindrical valve for emptying is protected from drift by screens, and consequently is less liable to damage. The liability of the balance valve in the gate to injury from drift or in other ways, and its difficulty of operation, render its use unsatisfactory for either filling or emptying valves under large heads.

The very satisfactory service of the cylindrical valves for emptying lock at Lock No. 9, since the completion of the lock in 1903, would seem to justify their use for this purpose for locks of high lifts, especially where there is room to have the discharge through horizontal culverts under sill.

Referring to the author's remarks on dams, I may state that in

general all dams should have an apron at the toe with top surface slightly above lower pool level, the surface either horizontal or slightly inclined upward in the downstream direction. Especially is this important in cases of slope dams when founded on piles, or where the foundation at toe is not rock. The apron will deflect the downward direction of the water passing over the dam, and prevent the material at the toe of the dam or along the bottom of abutment on river wall from being scoured out. Originally, Dam No. 1, Kentucky River, was a timber stepped dam, about half of which was on the piles. A few years ago this dam was repaired by resurfacing with concrete, the lower portion of dam below the crest being sloped to the lower face. The following winter the material below the dam was scoured out to such an alarming extent as to endanger the safety of the dam, and derrick stone was deposited at the toe. This did not prove effective, and an apron was built along the toe of dam. Since then the hole at toe of dam is rapidly filling with deposit.

At Lock No. 12 the concrete dam has a downstream slope of 45 degrees from crest to the elevation of lower pool, and then a gentler slope meeting the vertical face near the bottom. The dam is founded on shale or slate, and during the first winter after the completion of the dam, the dynamic force of the current striking the bottom has succeeded in scouring out a large amount of the slate below the dam, in some places to a depth of 3 or 4 feet below the bottom of dam and lock wall. It is quite possible that it will be necessary to do something to arrest this action.

Originally, Dams Nos. 1 to 8 on the Kentucky River, varying in lift from 12 to 18 feet, were timber dams with the downstream portion stepped. These are being resurfaced, changing downstream surface from a step dam to a slope dam with apron. This manner of repairing timber dams has proved very effective. The concrete surfacing is usually made from 3 to 4 feet thick, and the downstream portion should be made quite rich, or faced, to withstand the hammering action of the drift.

The dams on the Kentucky River differ widely in cross sections, but at certain stages of the river all of them retain more or less drift in the reaction below the crest, such being true also of the step dams. Those having the lower lift and longer downstream section have less reaction.

On western rivers, subject to frequent floods accompanied by much drift, the solid concrete dam is far preferable to any hollow reinforced dam which has been designed. It is believed that only a solid concrete dam would safely withstand the tremendous battering from drift in the reaction below the dam. The concrete of the downstream slope of dam should be rich, and should have considerable time to become thoroughly set before being exposed to heavy freshets.

Mr. Walker mentions the danger in locking boats having overhanging guards, when the water in lock is high enough to permit the guards to overhang the top of lock walls. On the Kentucky

River no trouble has been experienced in locking boats with the water near the top of lock wall. Most boats with overhanging guards have swinging fenders, which, when hanging free, strike below the water surface. When the boat is running, the lower ends of these fenders are swung on deck, but are lowered when the boat is locking, and prevent the guards from overhanging and fouling the top of the lock wall when the river is near the epoch of submergence. At this stage, the lock men usually remove the guard rails and valve levers from the gates to prevent possible damage from contact with the guards or fantail of the boat in entering or leaving the lock.

In determining the guard of a lock, it should first be decided whether the demands of commerce will be such as to warrant the construction of sufficient height to the guard that when the lock is submerged a safe passage may be made over the dam. Unless the demands of commerce are very great, it will be sufficient to establish the guard of wall so that passage may be made through the lock except during freshets occurring perhaps two or three times a year. The height of guard to meet these conditions may be best determined by studying the conditions on river where locks and dams already exist and gage observations have been made. For example, on the Kentucky River, Locks Nos. 1 to 5 have a lift averaging about 13 feet, and a guard from 9 to 10 feet. The lengths of the dams vary from 400 to 556 feet. At submergence of these locks, the fall generally varies from about 1 to 4 feet, and consequently navigation at this stage is suspended. The period of suspension is very short, as the river usually rises sufficiently to permit the safe passage of boats over the dams, or else falls sufficiently to permit locking. It has been observed that a boat with good power can go up over a dam with a fall of 1 foot, and down with from 1 to 2 foot fall. The dams on the upper portion of Kentucky River have an 18-foot lift, and a guard of 10 feet. The gage readings indicate that even at the highest stages of water, the fall over the dams is too great for the passage of boats. However, the guard of 10 feet is considered sufficient, for during the periods of submergence, which are infrequent and of short duration, the current is too swift for profitable navigation.

Referring to the author's statement "that some contend that by placing the lock and abutment well back into the bank, the increased length thus given to the dam would be efficient in reducing the fall, but such is believed to have no foundation in fact." I think the author is undoubtedly correct.

There is no question, however, but that an increase in length of dam will decrease the head on crest of dam, but in increasing the length of dam the cross section of the river above and below the dam is also increased, and in spreading out the same volume of water over a greater length of dam, the fall instead of being decreased is, of course, increased. The contention made probably is this: that with height of guard wall remaining the same, an in-

creased length of dam would decrease the fall at flood heights, or epoch submergence. In this case, the volume of water passing the dam at epoch submergence would be greater, but there would probably be very little difference in the fall from that with the shorter dam at the same height of upper pool. I think the chief benefit in increasing the length of dam would result from reducing the period of epoch submergence with the same height of guard. The reduction of fall under these conditions would be very slight. At Locks Nos. 9 and 10, Kentucky River, where the spillway has been greatly increased by auxiliary dams, but very little reduction in fall at high stages of water has been observed, but the lock is not submerged so quickly.

COMPARATIVE SECTIONS OF LOCK WALLS

BY

MR. E. H. BULLOCK
Junior Engineer

No theory can be fully relied upon unless it is substantiated by actual experiment or experience. It is a well known fact that none of the theories for the pressure of earth against a retaining wall agree with experiments or experience. Rankine's and Coulomb's theories, which reduce to the same thing, are expressed by the equation

$$P = \frac{1}{2} wh^2 \frac{(1-\sin\varphi)}{1 \div \sin\varphi}$$

when the filling behind the wall is not surcharged, as is the case with land walls of locks. The symbols in this equation are P= horizontal pressure of fill behind the wall; w=weight per cubic foot of the filling; h, the height of the wall; and φ the natural slope to the horizontal which the material of the fill will take unconfined. The weight of a cubic foot of the filling material can probably be determined with sufficient accuracy, but there are uncertainties here. We do not know how much moisture the material is going to collect after the fill is made, a fact on which the weight largely depends. The weight also depends on the chemical composition and the amount of vegetable matter present. It also varies for the different strata met with at the same site. Walls are generally designed with very little information at hand as to the character of material at the site and then the weight can be only a guess. The angle of repose of the filling material, φ, varies greatly with the amount of moisture contained. The character of the material, its chemical composition, the amount of vegetable matter contained, the size and shape of the particles, also affect the angle of repose. This angle is generally assumed at about the angle the earth is found to take on banks in the vicinity of the site. Quoting from an editorial in the Engineering News of Jan-

uary 26, 1893: "When a slippery film forms under it (the fill) somehow, so that its angle of repose is almost zero, it makes an immense difference whether the pressure comes from a small mass or from one extending outward and upward for a long distance. Approximately speaking, the pressure is about as great as if the wall were carried up as high as the highest point which is tending to move and filled in level behind."

If we knew that the fill behind a retaining wall would be properly made and suitable provision made for drainage, the values of w and φ could probably be assumed with sufficient accuracy, but as walls are usually built there is always danger of a distribution of the pressure entirely unlike that assumed in the calculations, as well as great probability of water collecting behind the wall, which will not only change the values of w and φ, but will also produce a hydrostatic pressure on the back of the wall.

It is a widely accepted rule in the design of walls to retain earth or water that the line of resultant pressure at any depth should cut the wall within its middle third at all places. The theory is that if it does not there will be an uplift at the back of the wall which ought not to occur in unreinforced concrete walls, and certainly not in stone walls.

The overturning moment in the land wall of a lock is partly resisted by the water in the lower pool, except occasionally when the lock chamber is pumped out. It is a doubtful question whether we should allow anything for the resisting moment of this water, or if anything, how much.

In walls with sloping backs, the earth vertically over the back may help to resist the overturning moment, but it is a disputed question. Sir Benjamin Baker states that "he has invariably observed that when a retaining wall moves by settlement or otherwise, it drops away from the filling and cavities are formed. A settlement of but one thirty-second of an inch, after the backing had become thoroughly consolidated, would suffice to relieve the offsets of all vertical pressure from the superimposed earth, and the latter can not therefore be properly considered as contributing to the moment of stability." But these cavities would further show that the filling material has a high degree of cohesion, while the formula for pressure is based on the assumption that there is no cohesion between the particles of the filling material. Whether or not we consider the pressure of the lower pool and the earth pressure vertically over the back slope of a land wall as resisting forces will make a large difference in the calculated stability of the wall.

The actual horizontal pressures on each side of the river wall are capable of accurate determination, but the great uncertainty here is whether we are ever safe in assuming that there is no leak under the bottom or between the successive layers in a stone wall. A wall on a pile foundation or any porous material should be designed on the assumption that there will be hydrostatic pressure on the entire base of the wall, which would require a reduction of the weight of the wall by the weight of the water displaced. But when the wall is on a solid rock foundation it is probably not safe to assume that there will be no hydrostatic pressure from beneath, and yet it would probably be further from the truth to assume that the pressure existed over the entire base.

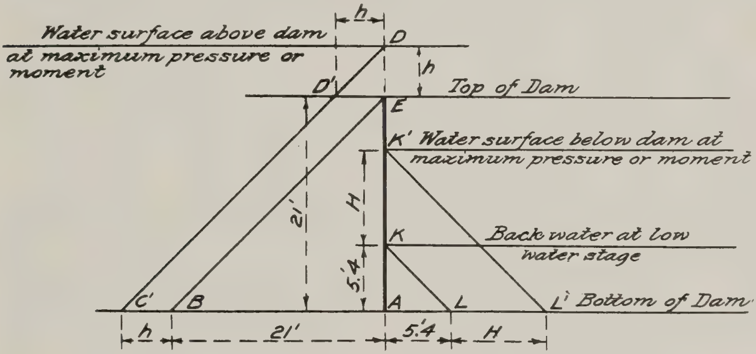


Fig. 1.

The illustrations show a number of land and river lock walls plotted to the same scale with the average thickness of each given in per cent of its height, together with the area of the section. These areas and mean thicknesses are given for the part of the wall above the footing, and no deduction is made for openings.

Let us test the stability of one of the thinner sections, according to Rankine's theory and the assumptions usually made. Take the land section of Lock No. 9, Muskingum River. No information is at hand as to the character of the filling material or how the fill was made, but we will assume that the natural slope, φ was about 1½ to 1, or, say, 30 degrees, and that the weight of the filling material was 100 pounds per cubic foot. Taking a section of the wall 1 foot long and substituting the values in the equation for earth pressure the equation reduces to

$$P = \frac{100}{6} h^2$$

and the moment of this force applied a distance of one-third the height of the wall above the base will be

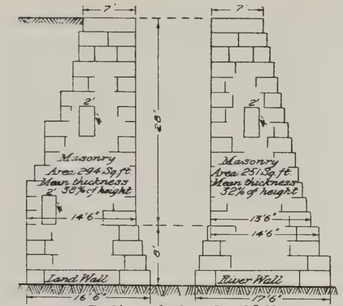
$$M = \frac{100}{18} h^3$$

M being the overturning moment. Substituting the value of $h =$ 31.5 feet, we find M to be 173,640 foot-pounds.

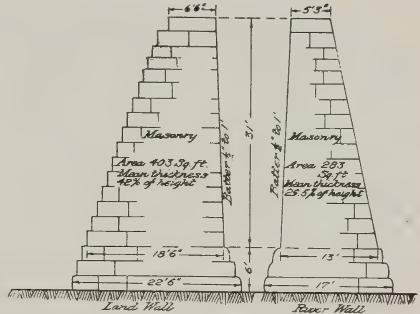
Assuming the masonry to weigh 150 pounds per cubic foot, the weight of the wall is 47,400 pounds, and the weight of the earth vertically over the back slope at 100 pounds per cubic foot is 13,400 pounds. The total resisting force is the sum of these two weights, the center of gravity of the sum being found to lie 6.47 feet from the front face of the wall.

The overturning moment divided by the weight will give the distance of the point of intersection of the line of resultant pressure with the base, called the center of pressure, from the center of gravity. This distance is found to be 2.85 feet. The center of gravity being 6.47 feet from the front face of the wall the center of pressure will be 6.47—2.85, or 3.62 feet from the front face or 1.21 feet outside the middle third of the base. This result will tend to show, either that the value of P as found by Rankine's formula is too great, or that there will be an uplift at the back of the wall, or that some of the assumptions made were erroneous. But the point that concerns us here is that the theories and assumptions do not agree with experience, because the wall has demonstrated the fact that it is stable.

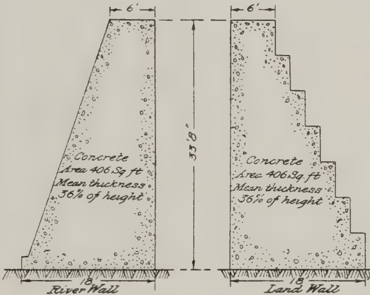
The formulæ for earth and water pressure show that the pressure increases as the square of the depth, which means that the most economical wall is the one that starts with the smallest practicable top width and continues to spread out as the depth increases. If the wall were designed strictly in accordance with the equation we would have a profile curving out more and more as the depth increased. The advantage gained by building this wall would not be great enough to compensate for the additional cost of construction, except in cases of very high walls, but we can approximate this more or less to advantage. We might build the wall rectangular with a width equal to the top width down to about the point where the center of pressure would strike the edge of the middle third, and then begin to spread out either by steps or by a series of straight lines, each more inclined to the vertical than the preceding. In any event, the less of the weight we have at the top, the more stable the wall is.



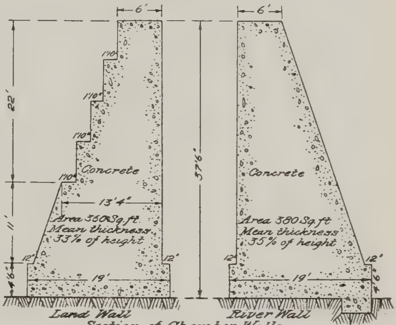
Section of Chamber Walls
MONONGAHELA RIVER-LOCK No.8.



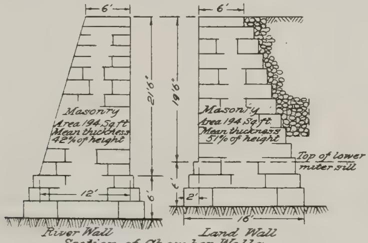
Section of Chamber Walls
GREAT KANAWHA RIVER-LOCK No.2.



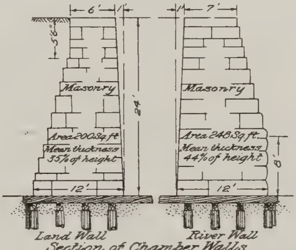
Section of Chamber Walls
CUMBERLAND RIVER-LOCK No.21.



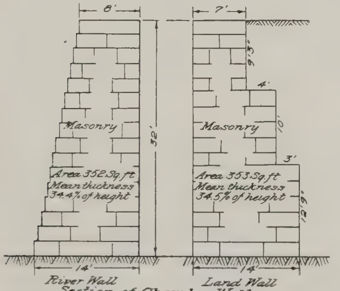
Section of Chamber Walls
KENTUCKY RIVER-LOCK No.12.



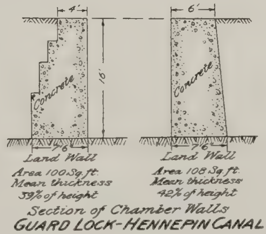
Section of Chamber Walls
GREAT KANAWHA RIVER-LOCK No.7



Section of Chamber Walls
ILLINOIS RIVER-KAMPSVILLE CANAL



Section of Chamber Walls
KENTUCKY RIVER-LOCK No.6



Section of Chamber Walls
GUARD LOCK-HENNEPIN CANAL

Plate I

Owing to the many uncertainties in the theories and assumptions made in the mathematical design of lock walls, the writer is of the opinion that the proper way to arrive at the dimensions of a section of a certain height is by comparison with sections of walls already built. From the numerous sections shown on the drawing we ought to be able to construct a rule that will give safe results.

Referring to the figures, it will be seen that the top width of walls varies from 4 feet to 12 feet 9 inches, the average being about 6 feet, which is probably the best width.

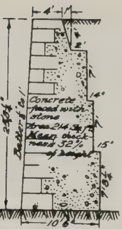
Some of the walls on rock foundations have footings projecting into the lock chamber. These are considered objectionable because there is danger of their breaking off on the land wall and they are useless on the river wall. If they are higher than the lower miter sill they will decrease the available width of the lock chamber.

When on soft foundations, footing on the land wall are necessary to equalize the pressure on the base. It is desirable to have the center of pressure uniformly distributed over the base as nearly as possible. In locks in India, founded on very soft and treacherous clay, the floor of the locks—which was made monolithic with the walls—generally cracked and raised up at the center of the lock chamber, showing that the earth pressure behind the walls was not sufficient to throw the center of pressure near enough to the center of the footing formed by the floor of the lock and the bottom of the walls.

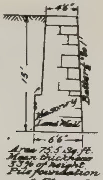
Only three of the locks shown on the figures have walls battered on the lock chamber side. It is the general rule in America to make the chamber faces vertical.

The river and land wall sections are made in nearly the same proportion, the land section being slightly heavier on an average. Referring to Lock No. 2, Great Kanawha River, we find the average thickness of the land wall to be 42 per cent of its height, while for the river wall only 29.5 per cent is shown. On the other hand, in the Kampsville Lock of the Illinois River we find the average thickness of the land wall only 35 per cent of its height, while that of the river wall is 44 per cent.

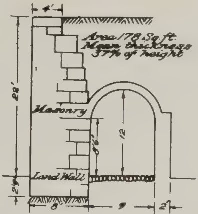
Among the best designed sections for rock foundations in the figures are those for Lock No. 8, Monongahela River; Lock No. 2, Great Kanawha River; Lock No. 21, Cumberland River; Lock No. 12, Kentucky River; Lock No. 9, Muskingum River; Lock No. 11, Kentucky River; Lock No. 2, Soulanges Canal; Sault Ste. Marie Lock; Cascades Canal; Lock B, Cumberland River, and



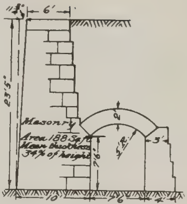
Section of Chamber Wall
OSWEGO LOCK
NEW YORK STATE CANALS
(Opens into Lake Ontario)



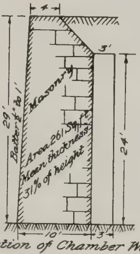
Section of Chamber Wall
EUREKA LOCK-FOX RIVER



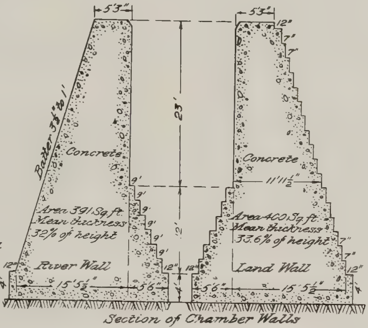
Section of Chamber Wall
LOCK-DAVIS ISLAND



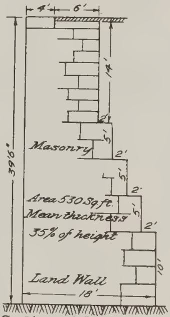
Section of Chamber Wall
DES MOINES RAPIDS LOCK



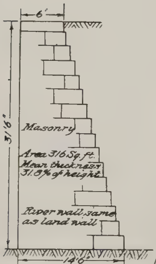
Section of Chamber Wall
WELLAND CANAL



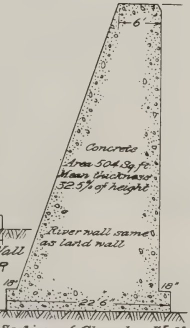
Section of Chamber Walls
LOCK NO. 2-BIG SANDY RIVER



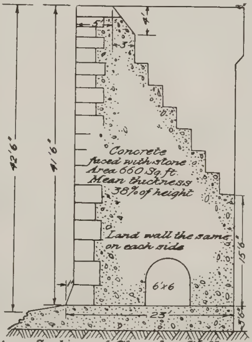
Section of Chamber Wall
SAULT ST. MARIE LOCK



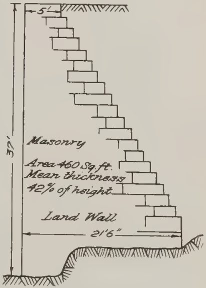
Section of Chamber Wall
MUSKINGUM RIVER
LOCK NO. 9.



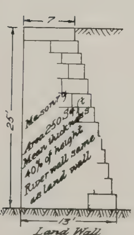
Section of Chamber Wall
KENTUCKY RIVER-LOCK NO. 11.



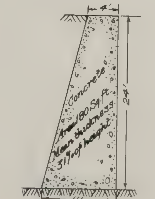
Section of Chamber Wall
SOULANGES CANAL-LOCK NO. 2



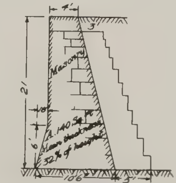
Section of Chamber Wall
COLBERT SHOALS CANAL



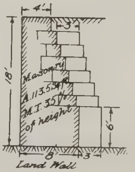
Land Wall
Section of
Chamber Wall
WABASH RIVER



Land Wall
Section of
Chamber Wall
HENNEPIN CANAL-LOCK 37



Land Wall
Section of Chamber Wall
MUSCLE SHOALS CANAL
The main body of the wall is the section lined area. In every 60 ft. of the wall there is a buttress as shown 10 ft. long



Land Wall
Section of Chamber Wall
GOOSA RIVER-LOCK 3
The section lined area is the main body of the wall. In every 43 ft. of the wall there is a buttress 12 ft. long as shown.

Plate II

Colbert Shoals Canal. The average of the average thicknesses of these sections is found to be 36.6 per cent of the height for the land wall, and 33.8 per cent for the river wall. The Colbert Shoals Canal walls have been built up 4½ feet higher with a thickness of 5 feet, which changes their average thickness from 42 per cent h to 34.3 per cent h. If we throw out the land section of Lock No. 2, Great Kanawha River, which is considerably heavier than any of the other sections taken, and take the new value for Colbert Shoals Canal, we have for the average thickness of land walls 35.4 per cent h.

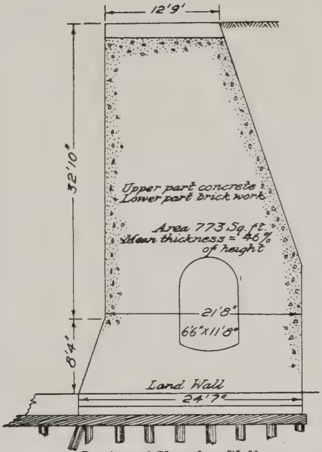
If we average all the sections shown, we have for the land walls 36.4 per cent h, and for the river walls 36.3 per cent h, for the average thickness.

A rule for average thickness, however, should not be based on the average of a number of sections, but on the minimum, or average of the minimum sections. As the majority of the sections for both land and river walls have an average thickness of 35 per cent of their height, or less, we would be safe in making the average thickness for both land and river walls 35 per cent of their height.

In Rivieres Canalisees, by F. B. DeMas, it is found that the walls of two hundred locks of the Eastern Canal of France having battered backs, a height of 19 feet 6¼ inches, and an average thickness of nearly 35 per cent of the height above the floor, have given excellent results.

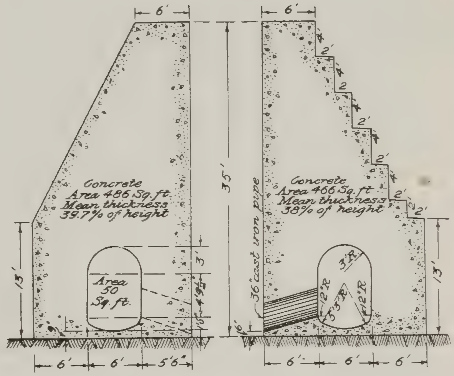
It may be of interest here to give the method employed by the writer for finding the stage of maximum pressure and moment on a wall subjected to varying stages of water on each side. In order to simplify the work the case of the dam for Lock B, Lower Cumberland River, will be taken.

It is assumed that there will be a fall of 3 feet over the dam at the epoch of submergence of the lock walls. Under this assumption, the lock having a guard of 15 feet, it is found that for each foot of rise on the dam there will be 1.84 feet rise in the lower pool above low water. Let h be the variable stage of the upper pool above the dam and H, equal to 1.84 h, the variable stage of the lower pool above low water. Taking a section of the dam 1 foot long, it is seen from Plate III that the areas of the trapezoids in square feet varying from A B E toward A C′ D′ E multiplied by 62.5 will give the varying pressures above the dam. Likewise, the varying areas to the right of A E multiplied by 62.5 will give



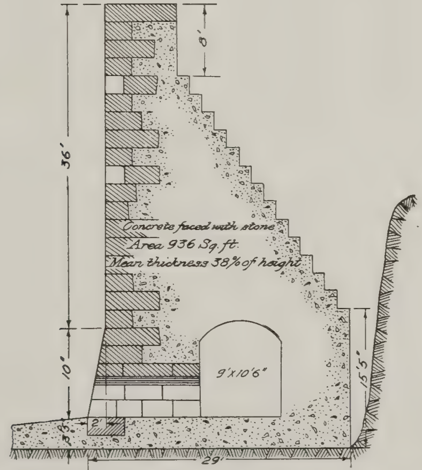
Section of Chamber Wall

THE NEW LOCK WEST OF TER NEUZEN, HOLLAND



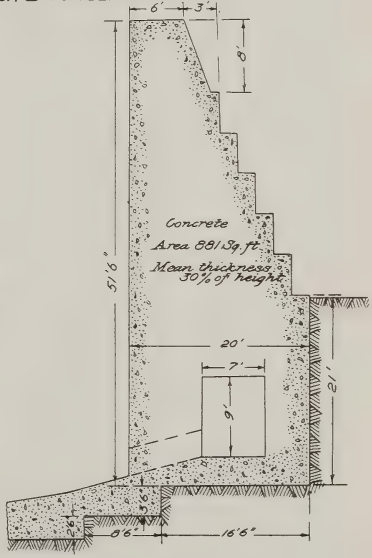
Section of Proposed Chamber Walls

LOCK 'B' CUMBERLAND RIVER



Section of Chamber Wall

CASCADES CANAL



Section of Chamber Wall

LOCK NO. 3, ERIE CANAL

Plate III

Plates I, II, and III were compiled by Mr. J. S. Walker, Assistant Engineer, under the direction of Maj. W. W. Harts, Corps of Engineers. The areas and mean thicknesses given are taken for the part of the wall above the footing, no deduction being made for openings.

the varying pressures below the dam. The areas A K L and A B E are constant.

Expressing the equation of the pressure in terms of the variables we have

$$62.5\left(\frac{21^2}{2}+21\,h-\frac{(5.4+H)^2}{2}\right)=P$$

After substituting H=1.84 *h* and reducing, we have

$$11.06\,h-1.69\,h^2+95.92=P\div 62.5;$$

making the first derivitive equal to zero, we have

$$11.06-3.38\ h=0.$$

Whence $h=3.2$ feet and $H=5.89$ feet, give the stages of upper and lower pools at the time of the maximum resultant pressure. Substituting these values in the above equation we find that pressure to be 14,000 pounds.

The maximum moment does not occur at the same stage as the maximum pressure and it is necessary to calculate this also. Expressing the equation for the moment in terms of the variables, we have

$$62.5\left[\left(\frac{21}{6}\right)^3+\left(\frac{21}{2}\right)^2 h-\frac{(5.4+H)^3}{6}\right]=M$$

After substituting H=1.84 *h* and reducing, we have

$$1517.26+193.67\,h-9.15\,h^2-1.04\,h^3=M.$$

Making the first derivitive equal to zero we have

$$3.12\,h^2+18.30\,h-193.67=0,$$

which gives $h-5.48$ and $H=10.08$. Substituting these values in the equation of the moment above, we have 133,350 foot-pounds for the maximum overturning moment.

The maximum pressure for the river wall can be found by the same principle.

If the dam is not designed so that the sheet of water passing over it will hug the lower slope, it is thought advisable to increase the pressure and moment as found above to provide for rarification on the lower slope. Frizell says that this pressure can not be greater than that due to one-third the head on the crest of the dam, and this value would be taken.

COST OF FORMS AT LOCK NO. 21, CUMBERLAND RIVER

BY

MR. JOHN S. BUTLER
Junior Engineer

In order that this paper may be better understood, a brief description of the lock and some of the features of its construction will be here given.

Lock No. 21, Cumberland River, is 28.75 miles by water below Burnside, Ky., this place being the nearest railway station. The river here is generally navigable for steamboats during the winter and spring months, and practically all of the heavy material and supplies for the work must be purchased and delivered during this period. It is not uncommon, however, in the low-water or working season, to have quick rises which cause delay, and unless prepared for, do serious damage to the work.

The lock walls, guide wall, dam, abutment, and toe walls are of plain concrete, while the curtain wall and footway for the guard wall are of reinforced concrete.

The lock is 386 feet long over all, with 280 feet by 52 feet as the effective size of the chamber. The top of the lock wall is 33 feet 8 inches above the concrete floor of the lock chamber. The guard is 12 feet and the maximum lift, with open river below, is 19.5 feet. The dam, which is of solid concrete, 340 feet long, has an ogee face on the lower side and a 20-foot concrete apron. This dam will give pool water up as far as Burnside, the head of navigation.

The guard wall, which presents some unusual features, is 160 feet long and is composed of seven concrete piers 10 feet long and 14 feet wide at the base, spaced 12 feet apart in the clear. These piers are joined on their face side with a vertical reinforced concrete curtain wall 3 feet thick and extending from 1 foot below the normal pool level to the top of the guard wall. There is a reinforced concrete walkway 1 foot thick extending over the piers and the curtain walls and joining the guard wall to the upper

end of the river wall of the lock, an 18-foot drift gap being left between the two structures. It will be seen that the guard wall, although resting on isolated piers, presents, to boats entering the lock, a smooth and continuous surface.

This work was carried on by contract for the first two seasons (1906-1907) during which time, it is said, the contractors lost $100,000. After the annulment of the contract, operations, by hired labor, were started June 1, 1908, under the direction of Maj. Wm. W. Harts, Corps of Engineers, U. S. Army, with the writer in local charge. The cost of the work by hired labor has been close to the contract prices.

The lock and guide wall were completed November 20, 1909. The abutment, toe walls, and guard wall were completed in December, 1910. Work on the concrete dam was not started in 1910 because of lack of funds.

During the present season of 1911, it is expected that the concrete dam will be built complete, thus making the lock operative.

LOCK WALL FORMS

While work on the lock was being done by contract, the style of form used for the construction of the concrete lock walls is shown on Plate I herewith. It will be seen that the trestle which was used for the delivery of the concrete was also used as a skeleton structure upon which the forms were built. The concrete for the lock walls was delivered from a central mixing plant over a 3-foot gage track on the trestle, in steel-bottom dump cars. From the bottom dump cars the concrete was delivered through a hopper car and chute to its place in the forms.

The forms were 6 by 15 foot panels, built of 1⅝ inch ship-lap lagging nailed to a framework of 3 by 10 inch pine timbers. The panels were fastened to 10 by 12 inch posts with ¾ inch lag screws. It was intended that the inside face of the panel be placed flush with the inside face of post, the post thus making part of the face of form; but it was soon found impracticable to keep the posts true to line, and to make a smooth joint between the panels, so the posts were set back 2 inches from the face line of the wall and the spaces between panels built in with a ⅞ inch dressed board. Neither the panels nor the posts were stiff enough to withstand the pressure from the green concrete, so heavy and expensive bracing was required. There was no provision made for moving

the heavy panels except by hand, and that proved to be a slow and expensive operation.

After the failure of the contractors and when operations were started at Lock No. 21 by hired labor, the use of the panel style of form was discontinued for the face of the lock walls as having proven unsatisfactory and uneconomical. However, these old forms were used to advantage on the back face of lock and wing walls where extreme care was not required and where derricks were available for moving the panels. When there is sufficient amount of uniform work, the panel style of form, when carefully designed and built, may be used with considerable economy of labor, material, and time, especially when machinery is available for moving the heavy panels.

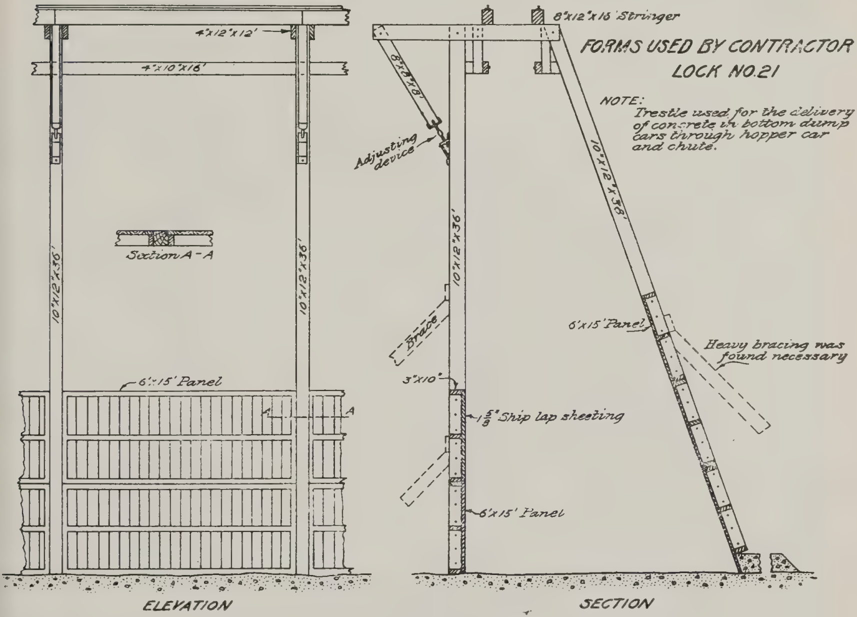


Plate I. Forms for River Wall, Lock No. 21, Cumberland River

It was considered best to retain the general arrangement of the concrete mixing and delivering plant for the lock walls, including the delivery track and trestle. The forms were modified with a view of obtaining a smoother and more rigid face, yet retaining the necessary features of the old plan. Plate II shows this new arrangement. The sheeting for the face of the wall was built continuously, and for this reason the posts were set back almost

6 inches from the face line of the wall. This sheeting was 2 by 10 inch pine "S 4 S." The studding was 2 by 8 inch and 3 by 8 inch pine spaced from 2 feet 6 inches to 3 foot centers. Old panels were generally used for the back of the forms. Tie rods of ⅝ inch round iron and cast iron sleeve nuts, as shown on Plate II, were used with very satisfactory results. The rods were placed in the forms only for one run of concrete at a time, so that they would not interfere with the movement of the concrete chute. When lumber became scarce the forms on the lower portion of a section would sometimes be removed before the completion of the top of the section. Generally, the wall was divided into sections 30 feet long. At one time the face form for a completed portion of the wall 100 feet long and 34 feet high was loosened and allowed to fall at one time into the lock chamber, this chamber having previously been allowed to fill with water to break the fall of the forms and prevent injury to the lumber.

FORMS FOR GUIDE WALL AND ABUTMENT

On account of the unstable nature of the banks and the large amount of excavation involved, it was decided to use shoring or timber support in making excavation for both the guide wall and the abutment, and on account of similar conditions and plant, the same style of timber support and concrete form was used on both places. This arrangement is shown on Plate III.

Placing this shoring and bracing was slow and tedious, as was also the removal of the braces while the concrete was being placed. The excavated material was removed by a derrick and placed behind the completed wall for back filling. The concrete was handled from a ½-yard Ransome mixer by a derrick, and with steel dump buckets placed directly into the forms.

The face form was 2 by 10 inch pine lagging, "S 4 S," carried on 2 by 8 inch pine studs placed about 30 inches, *c* to *c*. When practicable the form was braced to the timber support, and elsewhere, as near the top of the wall, ⅝ inch tie rods and sleeve nuts were used. These sleeve nuts, which were about 6 inches from face of wall, permitted the bolt ends to be removed after the concrete had hardened.

FORMS FOR GUARD WALL

These piers were built in the dry by means of a low earth cofferdam. The style of form for the piers is shown on Plate IV. A

trestle built independent of the forms was used for delivering the concrete from the central mixing plant in bottom dump cars. Forms were started on the first two piers at the same time, and as soon as the concrete in second stage of pier 1 was completed, the form timbers for the first stage of the first pier were moved to pier 3, and so on from pier to pier.

All piers were completed and forms removed before the forms for the reinforced curtain wall were started. Plate V shows the forms for the reinforced curtain wall or upper part of the guard wall. The 2 by 6 inch studding, which was all that was available for this work, was rather light, requiring a large number of tie rods to keep the forms from springing. Each 22-foot section, 13 feet deep, was completed in one operation, and as this work was done in freezing weather, causing the concrete to set much more

Fig. 1. Lock No. 21; Forms for River Walls

slowly than usual, there was an unusual amount of pressure on the forms, and considerable difficulty was experienced in holding the forms true to line. This curtain wall was built when the river was almost to the top of the piers, and as lumber was plentiful and labor scarce, forms were built the entire length of this wall, and the wall completed before any of the forms were removed.

FORMS FOR CONCRETE TOE WALL

These forms were built of rough oak boxing 1 inch thick and any old material available was used for studs. This oak boxing was seasoned and very uniform in thickness, so a very good face on the wall was obtained. The only trouble encountered was from caving banks and numerous floods. All forms were designed to meet the local conditions as to material on hand, labor, and arrangement of plant for handling concrete.

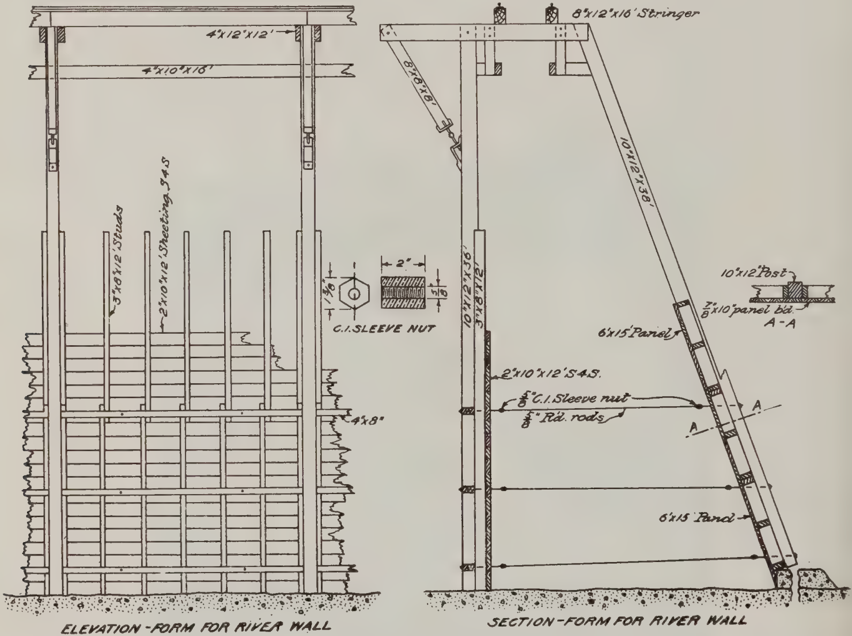


Plate II. Modified Forms for Lock No. 21, Cumberland River. Work done by hired labor. The trestle was used for the delivery of concrete in bottom dump cars, three hopper car and chute.

To my mind the most important feature of economical concrete construction, after considering the arrangement of the plant for handling the concrete material, is the careful study and design of

the forms, giving due consideration to the choice of standard lengths and sizes and grades of lumber, with not only a comparison of strengths of the various sizes, but also of the calculated loading to give the allowable maximum deflection. Careful consideration should be given to the minimum amount of lumber required to permit the forms to be kept ahead of the concrete, ample allowance being made for unexpected delay. The lumber should be used over and over as many times as its condition will permit.

To show the relation of the areas, strength, and resistance to deflection of various studs, with the 2 by 4 inch stud taken as unity in each case, the following table is submitted:

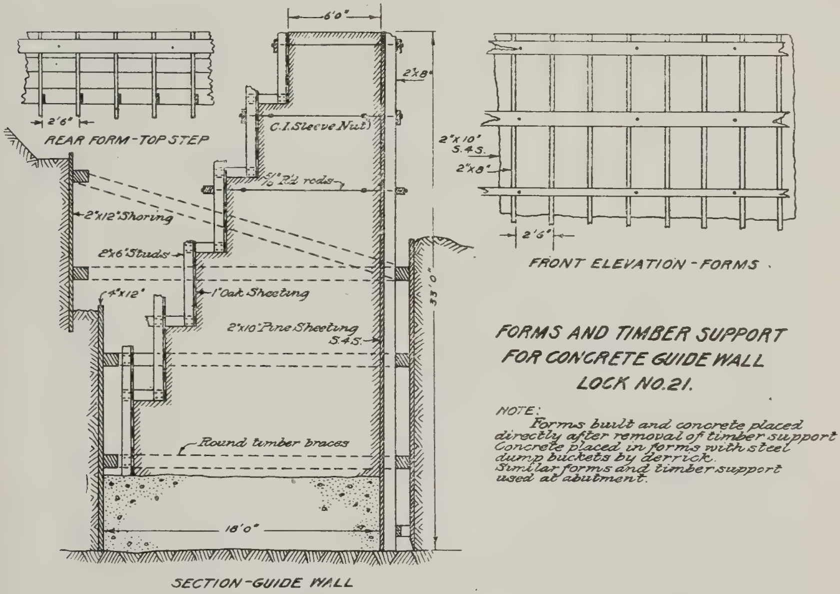


Plate III. Forms for Lock No. 21, Cumberland River

Size of stud	Area	Strength Flexure	Uniform load on 60″ fixed beam to give ⅛″ deflection
2 by 4 inches	1.0	1.00	1.00
2 by 6 inches	1.5	2.25	3.37
2 by 8 inches	2.0	4.00	8.00
2 by 10 inches	2.5	5.55	15.60
3 by 8 inches	3.0	6.00	12.00

For the style of form used and conditions at Lock No. 21, the 2 by 8 inch stud spaced about 30 inches "*c* to *c*" has been found the most economical.

These styles of forms as submitted herein are not without their imperfections, but they were the best we could devise with the means at hand. They were more economical and gave better results than the forms used by the contractor. The tie rod and sleeve nut were a decided improvement over the timber brace, and the continuous sheeting on the face of the wall gave a smoother and truer surface than was obtained with the panel.

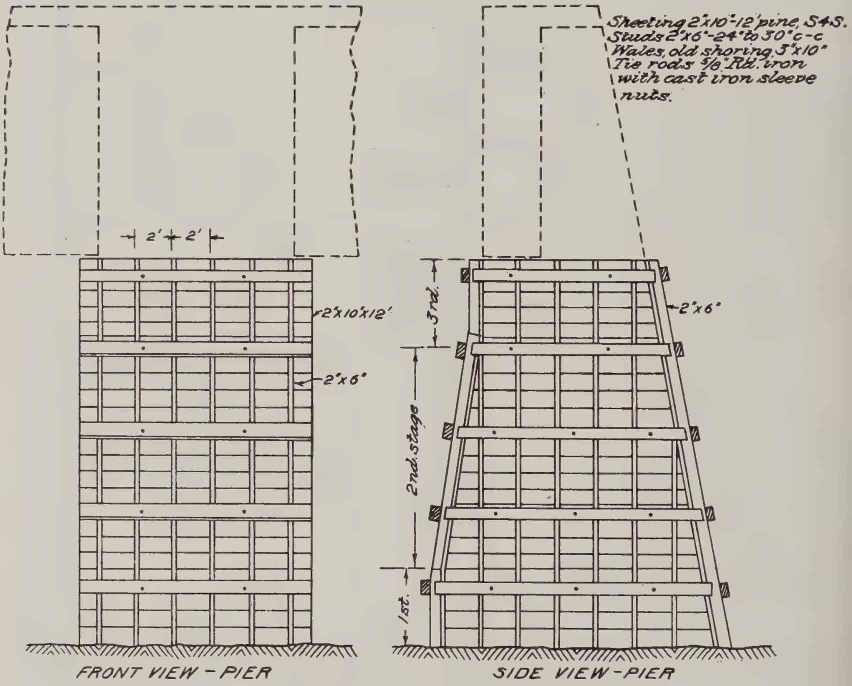


Plate IV. Forms for Guard Wall Piers of Lock No. 21, Cumberland River. The forms were built in three stages and were moved from pier to pier

The greatest objection to these forms, as well as to most all forms, is the cost and time required for erection. It will be seen that in some cases a large amount of lumber was tied up, but lumber was at times more plentiful and cheaper than the labor which would have been required to move the lumber from place to place.

UNIT COSTS AND COMPARISON WITH OTHER METHODS

Gillett, in his "Hand Book of Cost Data," says: "It is common practice to record the cost of forms in cents per cubic yard of concrete, giving separately the cost of lumber and labor. This should be done, but the analysis of the cost of forms should always be carried a step further. The records should be so kept as to show the first cost per thousand feet, board measure, of lumber, the number of times the lumber is used, the labor cost of erecting, and the labor cost of taking down the forms each time, all expressed in thousand feet board measure. Thus only is it possible to compare the cost of forms on different kinds of concrete work, and thus only can accurate predictions be made of cost of forms for concrete work having dimensions different from work previously done. It is well, also, to make record of the number of square feet

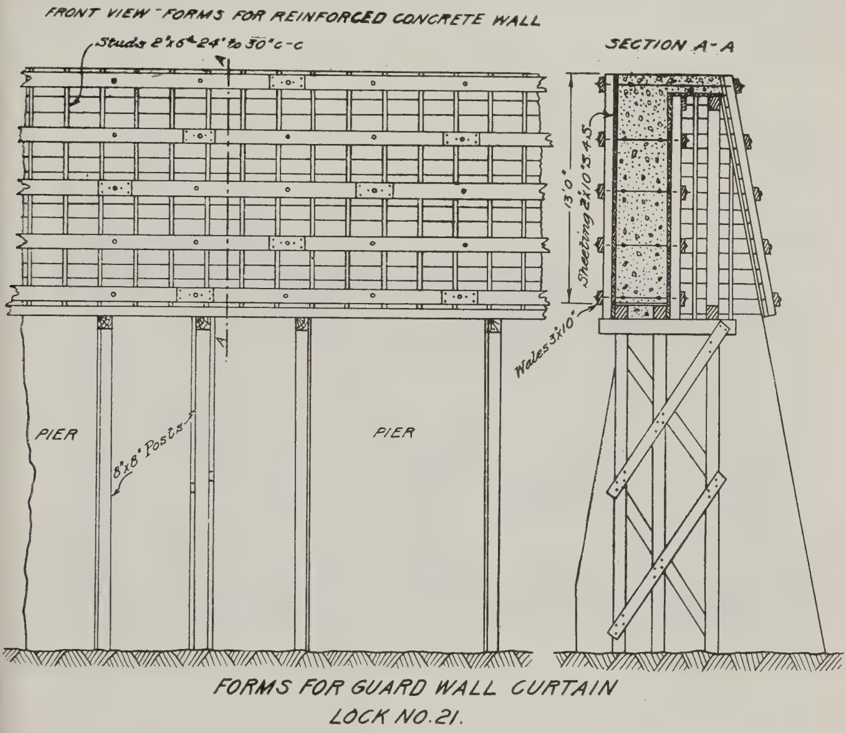


Plate V. Forms for Guard Wall Curtain, Lock No. 21, Cumberland River. Tie rods, ⅝-inch iron with cast-iron sleeve nuts. Stringers and caps, 8 by 10 inches. Wales and posts from old material on hand.

of exposed concrete surface to which the forms were applied. There are three ways, therefore, of recording the cost of forms:

1. In cents per cubic yard of concrete;
2. In cents per square foot of concrete face to which forms are applied;
3. In dollars per thousand feet board measure of lumber used.

In all three cases keeping the cost of material and labor separate. Furthermore, it is well to make a sketch of the forms and attach the sketch to the record of cost."

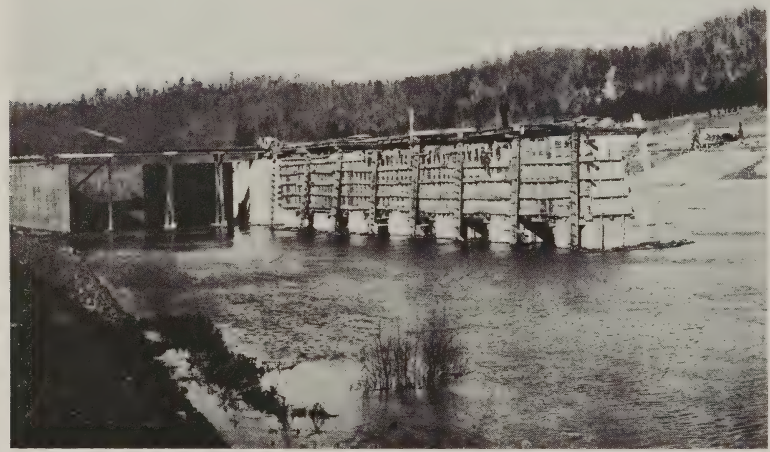


Fig. 2. Lock No. 21. Forms for Guard Wall Curtain

The cost of forms for work at Lock No. 21, as given below, seem to be high, but it should be remembered that this includes the cost of all labor and material for erection and removal, including the pro rata of general expense, as well as the additional cost of erection and maintenance of trestle bents and tracks for the delivery of concrete, and also the cost of the shoring and timber supports for the caving banks. The costs were further increased by the extreme care required to obtain and keep a true alignment of the face. Especial care was required in placing the cast iron hollow quoins.

Unit costs of forms for lock walls, including erection and maintenance of delivered trestle and tracks (10,215.7 cubic yards concrete).

	Total cost	Cost per cubic yard concrete
Material	$2,860.94	$.28
Labor	5,648.29	.54
Subsistence	961.34	.09
General expense	1,036.35	.11
Total	$10,506.92	$1.02

Unit costs of forms for guide wall, including costs of timber support (2,283.9 cubic yards concrete).

	Total cost	Cost per cubic yard concrete
Material	$765.41	$.335
Labor	758.49	.332
Subsistence	95 32	.042
General expense	92.33	.040
Total	$1,711.55	$.749

Unit cost of forms for abutment, including cost of timber support (2,833.6 cubic yards concrete).

	Total cost	Cost per cubic yard concrete
Material	$385.85	$.136
Labor	753.41	.265
Subsistence	184.26	.065
General expense	284.88	.101
Total	$1,608.40	$.567

Unit cost of forms for guard wall, including erecting and maintenance of delivery trestles and tracks (911.2 cubic yards concrete).

	Total cost	Cost per cubic yard concrete
Material	$454.70	$.499
Labor	1,108 47	1.216
Total	$1,563.17	$1.715

The excessive cost of the forms for the guard wall was due to frequent floods delaying and damaging the work, and to increased difficulties of the forms for the reinforced curtain walls.

Unit cost of forms for toe wall, including cost of shoring (625.3 cubic yards concrete).

	Total cost	Cost per cubic yard concrete
Labor	$341.55	$.548
Material: Old lumber, not charged.		

In "Concrete Construction," by Gillette and Hill, this statement is made: "It is seldom that form work, outside of very massive foundation construction, costs less than 50 cents per cubic yard of concrete in place, and it is not unusual in the more complex structures for it to cost $5.00 per cubic yard of concrete in place." The following examples of the cost of form work have been taken from Gillette and Hill's "Concrete Construction."

Work	Quantity of concrete, cubic yards	Cost per cubic yard concrete, labor and material	Remarks
Gun emplacement, Staten Island, N. Y.	9,387	$.95	Labor, $1.50 per day. Massive work.
Mortar battery platform, Tampa Bay, Fla.	8,994	.37	Lumber, $11.56 per M. Massive work.
Emplacement battery, Tampa Bay, Fla.	6,654	.22	Massive work.
Lock No. 31, Coosa River, Ala.	8,710	.42	Labor, $1.00 per day, 3″×10″ lagging, 6″×8″ posts, 5′ to 7′ c-c bracing.
Lock walls, etc., Illinois and Mississippi Canal:			
Two abutments	254	1.65*	2″ × 8″ s 2 S sheeting and 2″×8″ studs 2′ c-c.
Three piers	460	1.128*	Inclined braces used.
Guard lock	3,762	.923*	Labor, $1.50.
Lock No. 37	3,767	.907*	4″×8″ sheeting 8″×10″ studs 4′ c-c, braced with 8″×10″ timbers.
Lock No. 36	2,141	.79*	4″×8″ sheeting 8″×10″ studs 4′ c-c, braced with 8″×10″ timbers.
Lock No. 15	2,559	.79*	Labor, $.58, material, $.21. Timber used 5 times.
Lock No. 20	2,750	.547*	Labor only.

*Only one-fourth the cost of the lumber at $16.00 per M. charged to forms.

The available information concerning the cost of forms is very incomplete. The above examples, however, are sufficient to show that the unit costs of forms, even for similar classes of work, are quite variable; thus emphasizing the importance of giving careful study and consideration to the many questions entering into the economical design and construction of forms for concrete work.

RAILWAY TRANSPORTATION REQUIRED FOR A PIONEER BATTALION, U. S. ARMY

BY

CAPT. W. H. ROSE
Corps of Engineers

The following is a statement of the transportation required for movement by rail into the field of a pioneer battalion of Engineer troops, based on the organization and general equipment prescribed in the Field Service Regulations of 1910 and on the detailed equipment and allowances prescribed in General Orders No. 95, War Department, 1908. In case of conflict, the Field Service Regulations are assumed to govern as being of more recent date.

I. *Tabular statement of personnel, animals, and vehicles pertaining to Pioneer Battalion of Engineers*

	Officers	Enlisted men	Riding animals	Draft animals	Pack animals	Tool and map wagons. (Loaded)	Field wagons	Ambulances
3 Companies	12	492	90[†]	60	18	9	6	---
Headquarters	3	9	9[*]	8	---	1	1	---
Sanitary	3	9	9	---	---	---	---	1[‡]
Total	18	510	108	68	18	10	7	1

[*] Includes 1 lead horse for Major. Field Service Regulations, pages 40 and 43.
[†] Includes 6 riding mules.
[‡] No ambulance prescribed in Field Service Regulations.

II. *Tabular statement of personal baggage, rations, forage and horse equipment pertaining to Pioneer Battalion of Engineers in the field.*

	Barrack bags	Trunk lockers	Cots	Blanket rolls	Rations per day	Saddle animal equipments	Draft harness 4-mule sets	Pack equipments	Lbs. hay per day	Lbs. oats per day
Officers	18	18	18	---	18	---	---	---	---	---
Enlisted men	---	---	---	510	510	---	---	---	---	---
Horses (102)	---	---	---	---	---	102	---	---	1428	1224
Mules (92)	---	---	---	---	---	---	---	---	1288	828
Total	18	18	18	510	528	102	17	18	2716	2052

III. *Tabular statement of tentage, etc., except shelter tents pertaining to Pioneer Battalion of Engineers in the field*

	Common tents	Wall tents	Hospital tents	Tent stoves	Stove pipe joints	Stove pipe elbows
3 Compaines	3					
Headquarters	1					
Sanitary	1		2	2	14	4
Co. officers		9		9	63	18
Hdqr's. officers		2		2	14	4
Sanitary officers		2		2	14	4
Total	5	13	2	15	105	30

In addition to the above equipage as tabulated, there will be two field ranges with cooking utensils for each company, such ammunition as might be taken with the troops on the train, and a few miscellaneous articles listed in General Orders No. 95, War Department, 1908, for which no special provision need be made.

The Field Service Regulations, page 141, prescribe that in the field Engineer troops needing ammunition will draw it from the nearest ammunition wagon, so it is probable that in a movement into the field Engineer troops would only take with them one or two bandoliers per man, and no special provision need to be made for this so far as transportation is concerned.

An inspection of Table I and of the prescribed allowances of transportation for officers and enlisted men will show that for the personnel there will be required at least:

1 standard sleeper for 18 officers,
11 tourist sleepers for 510 enlisted men.

The tourist sleeper being assumed to contain sixteen sections and three men per section being allowed. A rough computation of the total number of cars of all kinds for the battalion shows that it will be necessary to divide the train into two sections, and therefore the requirements will be

2 standard sleepers,
12 tourist sleepers.

In case the standard sleepers can not be provided for the officers, a portion of one of the tourist sleepers in each section of the train will be curtained off for their accommodation, as prescribed in A. R., 1908, paragraph 1136.

Transportation must be provided for a total of 194 animals. The ordinary and palace stock cars carry 16 to 20 animals each, and the improved stock cars 20 to 24. On the assumption of 18 animals per car, 11 stock cars would be the minimum requirement.

Two kitchen cars, in the form of baggage cars equipped for cooking, should be provided; one for each section of the train.

The wagons and ambulance, if one be taken, will be carried on flat cars. It will be assumed that the tool wagons are loaded and that they will not be dismantled, but that the tongues will be removed. Each tool wagon, field wagon, and ambulance will require a floor space about 11½ feet long by 5½ feet wide. Flat cars range in length from 34 to 40 feet and are about 8½ feet wide. If the tongues only are removed three wagons can be loaded on each car. All seven field wagons can be loaded on one car if disassembled. As they would generally be needed immediately upon detraining, they had best be loaded in the same manner as the tool wagons. On this assumption, six flat cars will be needed for the wagons. If the field wagons are disassembled, five would suffice.

For the forage, box cars will be used. Each day's supply of hay (2,716 pounds) will occupy 225 cubic feet as baled, and each day's supply of oats (2,052 pounds) will occupy 75 cubic feet, a total of 300 cubic feet. Box cars vary widely in size, but the ordinary box car, with a rated capacity of 60,000 pounds, has a gross cubical content of approximately 2,200 cubic feet. Assuming the forage to be loaded to within 2 feet of the bottom of the rafters, and that a small space for handling is left opposite one door, the net loading space is about 1,500 cubic feet. One car would then carry five days' forage for the animals of the entire battalion, and one car for each of the two sections into which the train is divided will be sufficient for any movement that may be made in this country. For shorter journeys a portion of the forage car may be used for other purposes.

For transportation of property, including horse equipment, draft harness, pack equipment, tentage, etc., one box car per section will be sufficient.

For baggage, including barrack bags, trunk lockers and cots of officers and arms and blanket rolls of enlisted men and such rations as are not carried in the kitchen cars, one baggage car per section will be required.

The following are, then, the total requirements:

2 standard sleepers,
12 tourist sleepers,
11 stock cars,
6 flat cars (wagons),
4 box cars (forage and property),
2 baggage cars (baggage and rations),
2 kitchen cars.

The troops and cars may be divided equally between the two sections, but this will necessitate the splitting of one company.

A better make-up for the two sections, keeping the companies intact may be effected by assigning one company with four tourist sleepers to the first section and two companies with eight tourist sleepers to the second section, equalizing the sections by assigning to the first five of the six flat cars. This will separate the two companies in the second section from some of their wagons and animals en route, but as the first section will arrive at the point of detrainment first, the companies in the second section will find there wagons and animals waiting for them upon their arrival.

The make-up of the two sections from head to rear should be as follows:

First Section. One Company and Headquarters

1. Five flat cars (wagons),
2. One box car (property),
3. Six box cars (animals),
4. One box car (forage),
5. One baggage car (baggage and rations),
6. One kitchen car (kitchen and rations),
7. Four tourist sleepers (men),
8. One standard sleeper (officers).

Total, 20 cars.

Second Section. Two Companies

1. One flat car (wagons),
2. One box car (property),
3. Five stock cars (animals),
4. One box car (forage),
5. One baggage car (baggage),
6. Four tourist sleepers (men),
7. One kitchen car,
8. Four tourist sleepers (men),
9. One standard sleeper (officers).

Total, 19 cars.

In the Field Service Regulations the kitchen car is placed ahead of all the tourist sleepers. In the above make-up, the kitchen car for the second section is placed between the fourth and fifth tourist sleepers. This will enable each of the two company kitchens to be placed in the end of the kitchen car adjacent to the four tourist sleepers which the company occupies, so that rations can be issued from both ends of the car simultaneously. Only those rations which will be needed en route should be placed in the kitchen cars, and a passageway should be kept clear for the passage of officers,

train employees, etc. While the kitchen car has been located according to the Field Service Regulations in the first section, it is believed that even in this case the size of an Engineer company would make it advisable to place the kitchen car between the second and third tourist sleepers in order to facilitate the issue of rations.

For the transportation of the pioneer battalion into permanent camp there must be considered in addition to the impediments listed above certain additional articles of clothing and equipage which must be taken. These additional articles come from the increased allowances for permanent camps, as given in General Orders No. 95, War Department, 1908, and the princpal items are listed below. The numbers do not correspond exactly to those given in General Orders No. 95, for the reason that a different organization of the Engineer battalion was contemplated in that order. However, it is believed that in the changes which have been made the intent of the order has been complied with, and that the numbers given represent the allowances that would be made for the present organization.

Surplus Clothing and Blankets. (*Will probably be packed in squad lockers.*)

510 cots,
510 barrack bags,
4 common tents,
67 conical wall tents,
6 wall tents,
Tent poles, pins, etc.
73 tent stoves,
511 joints stove pipe,
146 stove pipe elbows,
4 field desks,
2 field safes,
1 odorless excavator,
4 latrine troughs,*
4 urinal troughs,*
24 garbage cans,*
3 incinerators,*
6 paulins.*
Miscellaneous tools, stationery, etc.

For these extra supplies two box cars and one flat car should be supplied. One box car should be attached to each of the two train sections as before listed, and the flat car to the second section, making twenty-one cars in each section.

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*Will probably be shipped by Quartemaster's Department direct to camp. See General Orders No. 95, 1908, pages 25 and 26.

HARBOR IMPROVEMENT ON THE PACIFIC COAST OF THE UNITED STATES*

BY

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Corps of Engineers, U. S. Army, Assoc. Inst. C. E., M. Am. Soc. C. E.

Harbor engineering has long been known as a very difficult branch of a complex science. It deals with powerful and often destructive forces, which frequently defy the means of control available. The necessary magnitude and high cost of the works make successful examples of much utility, and a careful analysis of the conditions met with and the methods of improvements adopted in such instances should be of help to the engineer having this class of work to design. Several years' charge of certain harbor works in the northern portion of the Pacific Coast of the United States has emboldened the author to offer some observations concerning this class of improvements.

The natural conditions on the Pacific Coast—the slope to the ocean floor, the tidal flow, the intensity of the storms, and the physical nature of the coast—are in many respects peculiar. There are but few harbors, and most of those now in use have required a strenuous combat with the sea to maintain them in navigable condition. The results have been so instructive that a description of the harbors and their treatment should be of value to those interested in this kind of work.

DESCRIPTION OF THE COAST

The northern Pacific Coast of the United States is rugged in the extreme. The coastal range of mountains stretches in a continuous chain from Puget Sound on the north to San Francisco Bay on the south, except where broken by the Columbia River. This range lies about 20 miles inland from the coast line, and at intervals sends out spurs which jut into the ocean, forming bold and picturesque headlands. Between these heads are deep bights having low, sandy beaches. The few harbors met with lie in these bights, and have characteristics alike in many particulars. In several instances they afford access to considerable settlements which depend altogether on water transportation as the only practicable method of marketing their coal, timber, dairy products, and stock, some of which are produced at each place of any importance. Railway lines have just begun to pierce the coast range, a proceeding attended with much difficulty and expense, but the sea will always offer an advantageous line of communication if the harbors are improved and maintained.

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The headlands are mainly composed of soft metamorphic sandstone of the tertiary age overlying granite; although basalt is encountered at Cape Foulweather, where it outcrops. These headlands, exposed as they are to the furious action of the southwest storms, have contributed by their disintegration and erosion vast quantities of fine sand, overlying the ocean bottom and forming beaches of great length and unusual continuity. It seems probable that the same forces which wear away the headlands tend to close the bights between with continuous sand beaches. The fine sand of the beaches and ocean bottom is easily transported when dislodged by the waves and currents, and readily drifts with the wind when above the water-levels. These beaches are accordingly subject to change under the action of waves and winds, so that in many places sand dunes of considerable height have been formed by wind action, and sand spits of considerable length created; while channels through the beaches are occasionally entirely closed. The entrances to the harbors are thus exposed to the closing action of this body of moving sand, against which the steady but powerful erosive action of the tides struggles to maintain openings to permit the ebb and flow in the bays. The action of storms upon the coast-line is intensified by the sharp inclination seaward of the ocean floor, permitting waves of great force to break crest upon the shore line, frequently dislodging large masses of sand from the ocean bottom and hurling these masses upon the beaches with terrific force.

The 100-fathom contour is about 20 miles from the shore along the State of Washington, about 10 miles off along the State of Oregon, and about 6 miles off along the northern part of California. Farther south it approaches even nearer, lying about 4 miles off shore near San Diego. Opposite the Columbia River the 500-fathom contour is only about 30 miles off shore, and the 50-fathom contour only about 5 miles. It is thus seen that deep water is comparatively close inshore, and compared with many other sea fronts the bottom is far steeper and much more exposed.

There being no land within a reasonable distance in the Pacific Ocean to break the force of storms, their full force is felt on the coast-line and harbor entrances. Nor is there even shoal water sufficiently near to absorb the shock of storms, so that whatever means of harbor improvements are adopted must be exposed to the battering effect of unimpeded waves. Frequently seas of great fury break upon the shore when no storm has been felt on land—the power of the waves having been transmitted from storms at great distances, perhaps hundreds of miles at sea.

Passing up the coast northward from San Francisco, the intensity of storms increases, reaching a maximum between Cape Blanco and Cape Foulweather, and diminishing somewhat from there northward. South of San Francisco their force is much modified and their frequency lessened. The worst storms are those of the winter season. They commence usually in the southeast, veering to the south and increasing in violence until they reach the southwest quarter, where they acquire their greatest intensity, finally expending their power as they pass farther to the westward. These storms are frequently of several days' duration, and occasionally follow one another in rapid succession; but they are always most violent while in the southwest. The waves at such times have been seen to "break" in 8 and 10 fathoms depth. In the summer time the hardest storms are from the northwest, but they by no means equal in severity or frequency those of the winter season.

All these storms set up shore currents parallel to the coast, usually northward in winter and southward in summer; although it has been thought that the Japanese current has some effect, in the summer time, in producing eddy currents along the shore. These littoral currents are feeble at most times, but occasionally reach a velocity of 2 or 3 knots. They are doubtless mainly due to the fact that severe storms seldom blow directly on shore, but come mostly from an oblique direction, either from the northwest or southwest, causing a ''racing'' of waves along the shore and a characteristic transport of material along the beaches in the well-known zigzag directions. It was with many misgivings that the improvement of these harbors, in the face of this exposure and the likelihood of early destruction of the works, was commenced by the Government engineers. Many discouraging losses had to be endured before the results were beyond question, and often storms destroyed in a single night the result of weeks of effort. Such works as were finally decided upon, however, have been materially helped by the peculiar tides of this locality.

In each lunar day there are two high tides and two low tides of unequal height. Their sequence is from extreme low water to an intermediate high tide, thence back to intermediate low tide, thence up to extreme high tide, and thence down to extreme low tide. These tides are ordinarily known, respectively, as the ''lower high,'' ''higher low,'' ''higher high,'' and ''lower low.'' The drop from extreme high to extreme low, during spring tides, is known locally as the ''long runout.'' It is of the greatest effect in deepening the channels; its value being many times that of the weaker ''neaps.'' The ordinary range of tide is about 5 to 8 feet, except in Puget Sound, where local conditions affect it to a marked degree. During the ''long runout,'' however, this range often increases in some places to 12 or 15 feet. The datum for reference in surveys is always the plane of the mean of the ''lower low'' waters. The amplitude of the tidal wave gradually increases from San Francisco to Puget Sound, passing up the coast.

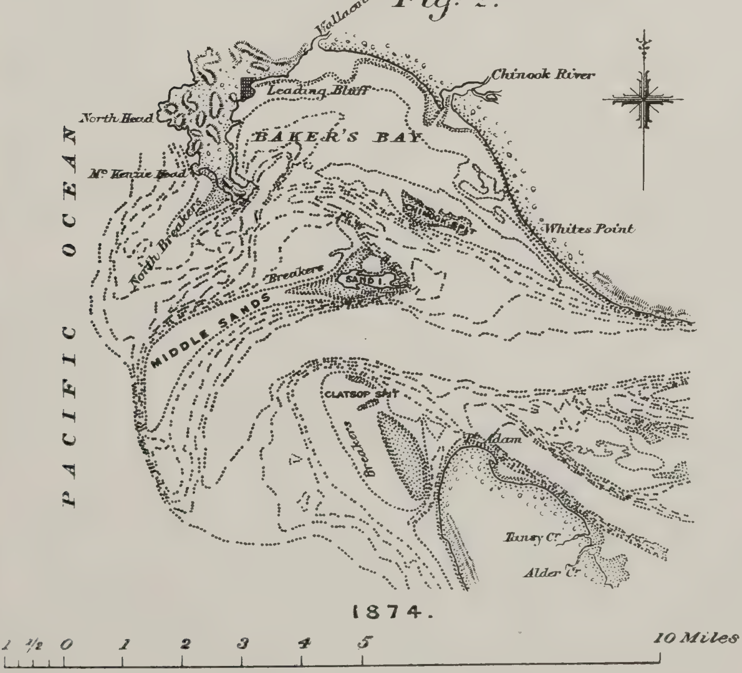
HARBORS

In the 800 miles of coast from San Francisco to Puget Sound the number of good harbors is so small that the United States Government is now making every effort to put the few that are available in such condition as will facilitate their use. These harbors are noticeably alike in many particulars. In general, they consist of a large interior tidal basin, the entrance to which lies between a high headland on one side and a long, low sand spit on the other. At one locality the headland will be found to the right of the entrance, and at another to the left. In a very few instances, such as at Humboldt Bay, the entrance is between sand spits on both sides; and in such cases the headland will usually be found a considerable distance back along the shore. The entrance channels vary in depth and directness, depending upon the resultant effect of the forces at work. In all cases, however, the harbor entrance is obstructed by a crescent-shaped encircling bar, at distances varying between 1½ miles and 8¾ miles from the entrance. The distance and the depth of water overlying the bars are largely dependent upon the area of the tidal prism within the bays and the exposure to storm action; and it is obvious that the process of their formation is much the same at each locality and that the remedies found helpful at one place might prove applicable at

Fig: 1.

1839.

Fig: 2.



1874.

Mouth of the Columbia River

another, if the reasons underlying the success of the methods employed can be thoroughly ascertained.

BARS

From an examination of the bars and an analysis of the forces at work a fairly clear idea may be gained of the usual process of bar-formation in this region. The constant effort of the seas during storms seems to be to close all openings in the beaches by filling them with sand dislodged from the bottom or the beaches by the breaking waves, and to heap up ridges and dunes of the material of which the bottom is formed; as if for the purpose of establishing a continuous and uniform shore line. On the other hand, before these ridges can be raised sufficiently high to close the entrances completely, the tidal current in passing in and out of the bay twice daily tends to neutralize these results; the conditions at a given time being the resultant of these several varying forces. The wind later piles up the sand in drifts after the beaches are formed, and on these dunes plant life collects and serves to gather still more of the drifting material.

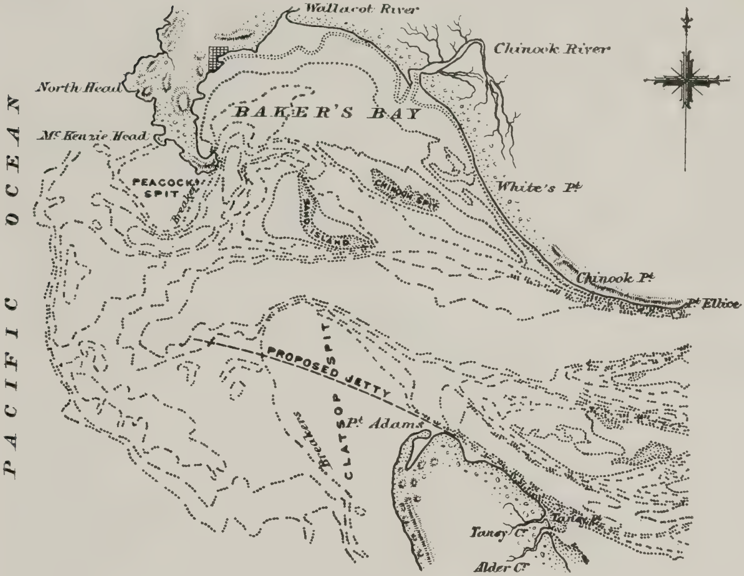
Usually the location of the channel at the entrance to the bay passes through a number of successive transitions, more or less regular in point of time, so that approximately periodical cycles of change have been observed at several places. It usually happens that the discharge from the bay is crowded north or south, depending upon the effect of the predominating littoral currents of the locality. As the tidal outflow is impinged upon more and more, the channel is gradually diverted to the leeward. This effect continues until the outflowing tidal channel has been turned aside and follows for a considerable distance along the shore; the enclosing bar building up as the channel is extended alongshore. Finally the strain on the bar from the additional head caused by the greater distance the water must travel is sufficient to enable the channel to cut through the sand spit at the weakest place, giving usually an outlet direct to sea. Often this cut occurs suddenly during storms, but generally it is a more gradual process. The formation of this new entrance has been usually called the ''breakout,'' and the channel immediately resulting presents the best depths that exist under natural conditions. Shortly after such a breakout the effect of the littoral currents begins to divert the channel to one side of the entrance, thus commencing another cycle. These cycles often occupy a number of years.

Except in the case of the Columbia River at flood stage, it may be assumed that the action of fresh water is a negligible factor; the quantities entering these bays being insignificant in comparison with the tidal flow. The main forces at work, therefore, are the storms, on the one hand, endeavoring to close the entrances; and the tides on the other, endeavoring to scour out channels for themselves. The action of these simple forces is modified in each instance by the size of the bay, the shape and topography of the entrance, the littoral currents, and many other influences, the full measure of which can not always be ascertained.

It will be noticed that in the throat or gorge at each harbor entrance excessive depths are found. This is unquestionably due to the fact that at this point the tidal discharge of the bay is concentrated; the flood and ebb currents both passing through the same channel, which is contracted to a marked degree. These depths are often several times greater than the depths of the channels within the bay or those over the encircling bar lying off shore.

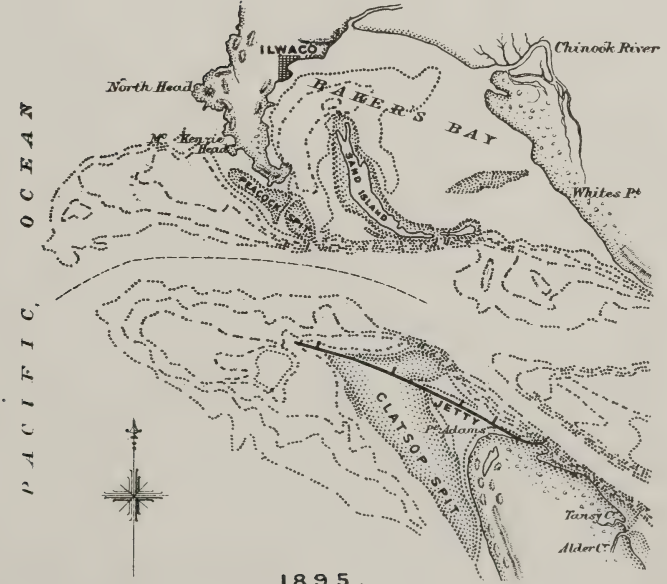
As the water passes out of the bay on the ebb tide, it is confined within

Fig: 3.



1881.

Fig. 4.



1895.

Mouth of the Columbia River

narrow limits at the gorge, where the velocities are considerable (sometimes as high as 4½ miles per hour) and the depths extreme. When this powerful discharge, all parts of which are moving forward in the same general direction, passes out beyond the gorge, the filaments of the tidal flow begin to spread out in fan shape, gradually losing their velocity as they mingle more and more with the quiet water of the ocean. Any sediment held in suspension will of course be dropped as soon as the velocity is reduced below a carrying value. Accordingly, as these currents become neutralized the material dislodged and carried along by the swift tide through the restricted places will be deposited along a curve in the ocean, all points of which are approximately the same distance from the outlet. This will easily account for the crescent shape of the cordon.

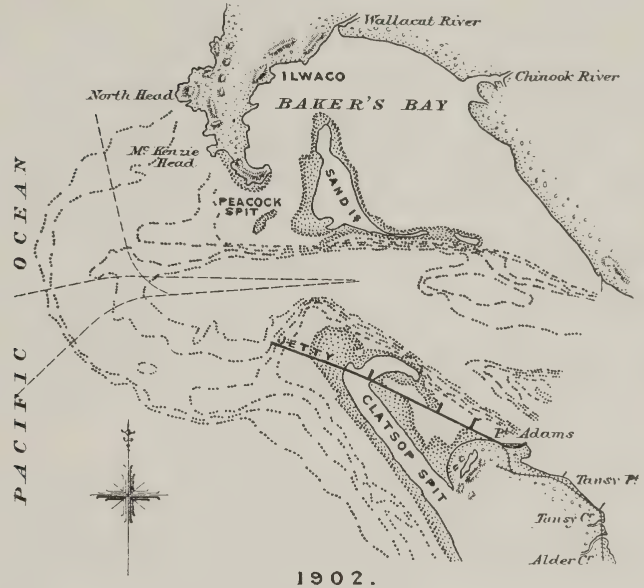
During storms sand is carried shoreward along the ocean floor and into the harbor entrances, while the constant effort of the ebb tide is to carry it back seaward. It is probable that sand particles may be transported to and fro across the bar many times under this continual struggle for mastery; the particles finally coming to rest where the current action is least. The bar with its shoal depths thus represents in a way the resultant of these opposing forces.

This theory of bar formation in this region seems well supported by observed facts, and suggests an obvious remedy which has been adopted, namely, to concentrate these divergent currents (by means of jetties of rock) at selected place along the bar sufficiently to enable them to cut a deep channel through it and prevent the accumulation of any more sand at the point determined upon, thus conserving the energy of the ebb tide and causing it to expend its force in useful work. The action of the currents in the ''breakout'' already described indicates that this method should be successful, inasmuch as in such cases the bar channel is narrow, deep, and direct, and the currents concentrated rather than dispersed.

The frequent changes which take place in these bars indicate that no artificial channels could be expected to withstand for any length of time the tendency of the sea storms to close all entrances. Instances have been known where bars have shoaled several feet in a single storm, but after the return of fair weather the scouring action of the ebb tide, when given an opportunity by contracting works, has removed the obstructing sand sometimes even below its former depth. It therefore seems probable that any deepening of the channels by dredging would not be sufficiently permanent, of itself, to warrant the application of that method. Attempts at improvement by dredging have already been made in the mouth of the Columbia River, but the results have not been encouraging, and dredging is not favored, except as an auxiliary.

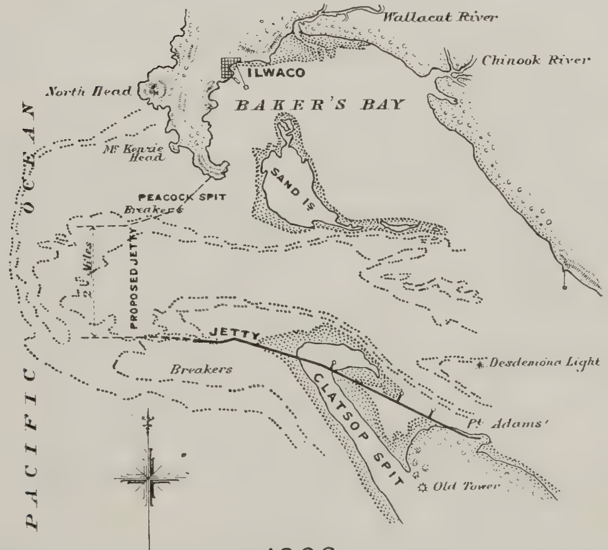
The efforts of the Government engineers are therefore directed to confining the outflowing currents so as to combine several useful functions. It seems necessary, first, to prevent the dissipation of the ebb currents until they can deposit the moving sand at safe depths, beyond the reach of storm waves, and in littoral currents where it will be carried away and not again help to form a bar; second, to protect the entrance from being filled by the sand carried along the shore during storms by littoral currents; and, third, to carry this regulating and protecting work in the direction that will provide an entrance channel most suitable for navigation and most likely to remain permanent. For

Fig: 5.



1902.

Fig: 6.



1908.

Mouth of the Columbia River

the fulfillment of these conditions it has been found that twin jetties are necessary, converging somewat as they extend from their bases on shore out to the bar. Furthermore, in view of the violent action of the seas upon all structures placed in such exposed locations, it was necessary to devise some method of construction by which the works might be preserved from the destructive forces of the storms and from the undermining scour of the tidal currents. After much deliberation and study it was decided to create sand spits lying along predetermined lines and held in place by a backbone of riprap, so located and built as to catch and hold the loose moving sand of the locality. In this way it was thought that the most economical results could be expected and the most permanent improvement secured.

By building dikes or jetties of random stone of large size, along properly situated lines, substantial backing can be secured by impounding the sand on both sides of the structure, thus binding it together and giving it strength to resist much of the shock of the outside sea waves and the scour of the inside tidal currents. These results have usually been secured by a good trace; but the proper location of the structures is a complex feature which requires careful study.

It is not always practicable to obtain jetty lines which will satisfy all the conditions, but they may be at least approximated. The design to be adopted will always depend to an important degree on the sand movement, which must be thoroughly studied, together with the action of storms and the needs of navigation. This study has usually been made by obtaining all the charts available, and observing, as far as possible, the trend of change. The free end of the enveloping sand spit usually shows the direction of the resultant of the local sand movement, and the cyclic swing of the channel indicates the quarter from which comes the resultant sand pressure.

Although each harbor must be studied and its problem solved in the light of all information obtainable, there are a few general principles which are common to most of the plans thus far carried out. For example, the principle of twin converging jetties is now adopted at each improvement. Single jetties have been urged by some engineers, but from the nature of the bar formation it seems obvious that a single jetty performs but a partial service. To obtain the full effect of the scouring action of ebbs, these currents must be held to their work by more contraction than is afforded by one jetty. This partial service may, however, be of sufficient effect to produce depths adequate to the needs of navigation for a number of years, as is now the case at Coos Bay; but, on the other hand, the hopes of those who relied on this method of improving Gray's Harbor were disappointed, and a second jetty has been commenced to secure the benefits confidently expected from the one first constructed. In some cases a natural promontory may take the place of the second jetty, as at the mouth of the Columbia River, where Cape Disappointment extends out from the north side of the bay, holding the currents to their work on that side of the channel.

Many theories have been advanced tending to show that a single jetty of special shape and location could be relied upon to do the work of two jetties at a much less total cost. Some of these single jetties have been curved in plan, some designs even showing reflex curves; and some have not been connected with the shore. Various claims have been made for a trace concave to

Fig: 7.

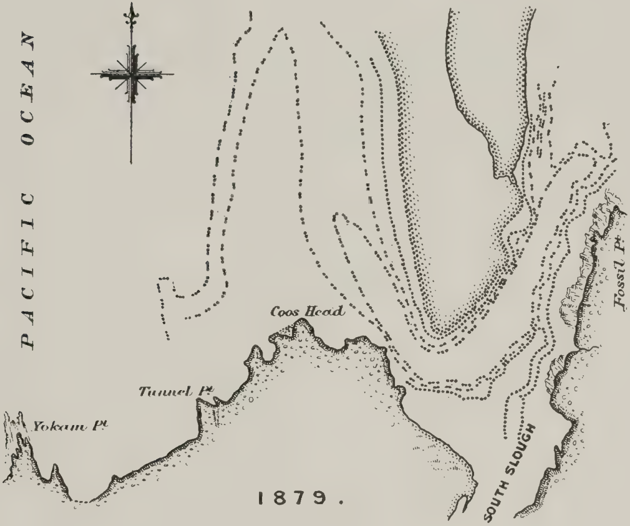
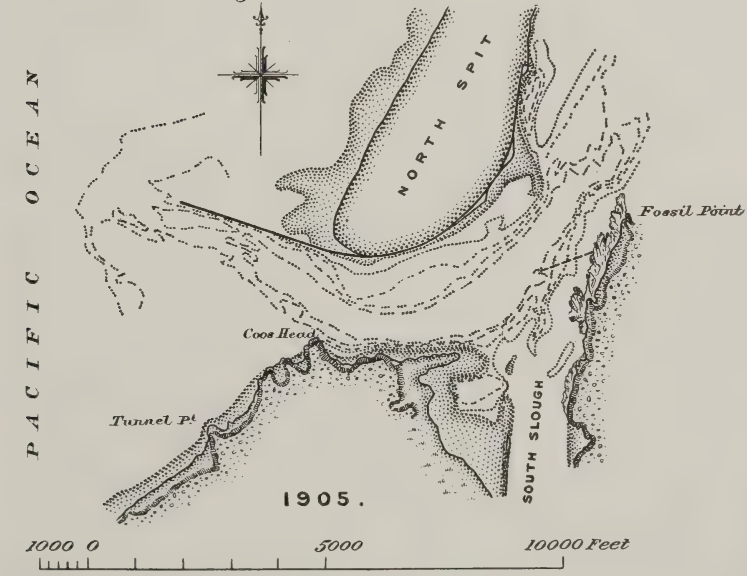


Fig: 8.



Entrance to Coos Bay

the current, to simulate the concave bank of a river; and the open gap advocated by some between the jetty and the shore was relied on to permit the easy ingress of flood tides. One such jetty has actually been constructed at Aransas Pass, in the Gulf of Mexico, but beyond a slight increase of depth in the concave part of the jetty, which was too close to be easily navigable, and even threatened the existence of the jetty itself through its undermining influence, no important or useful effect has been produced. This design has been unsuccessful and the hopes of its designers have not been fulfilled. The outer curved end of this jetty is now about to be removed, and a second jetty constructed on the opposite side of the bay in accordance with the twin jetty principles found satisfactory elsewhere. At all harbors on the Pacific Coast of the United States double jetties have been either actually built or are provided for by existing projects of improvement.

A second principle in the design of the works is that any delicate refinement of the trace of the jetty is not of much importance, but its correct general location is of great moment. It is customary to place the shore ends of these jetties a considerable distance apart and to draw them together at their outer ends in curves convex to the channel. This general design is of value in two ways; first, by affording a satisfactory shape for the groin, or angle of the jetty, making the collection of sand outside the channel more complete; second, in making it more difficult for racing currents within the bay to undermine the jetty, since the latter is constantly bearing away from their direction. When this shape is not entirely sufficient of itself for the purpose, short spurs have been found efficacious in collecting sand on the interior side to protect the jetty from erosion. By spacing the shore ends of the jetties far apart the sluicing basin is increased in area, adding to the ebb scour; but this feature is more particularly of value in reducing the wave action of the sea, since waves passing through the narrow entrance expand over a greater area on entering the bay and lose in amplitude and power.

Another general principle is that the windward jetty should be the first to be constructed, whenever the two jetties are not built simultaneously. This appears obvious, as it is seen that in no other way can the moving sand be so easily impounded and the new channel protected from sand encroachment at the same time. Neglect of this principle has caused considerable delay in obtaining good results at the mouth of the St. Johns River, Florida, at the entrance to Cumberland Sound, Georgia, and at the mouth of the Siuslaw River, Oregon, where in each case the wrong jetty was built first. As the work at these places was extended seaward the channel was forced against the jetty by the sand flow, narrowed, and then deflected at the outer end of the jetty in the direction of the sand drift. When the opposite jetty had been built to a sufficient length and height to control the currents, in the first two instances just mentioned, the scouring currents were held to their work without the interference of the littoral drift. The channels were then able to form anew, and began at once to straighten and improve. At St. Johns River the channels, formerly 5 to 7 feet deep, have now a depth of 24 feet, and at Cumberland Sound, Georgia, channels which had but 10 feet or 12 feet of water are now permanently 24.5 feet deep.

The location of the windward jetty is also a matter of much concern, as it determines the position of the entrance. Ease of navigation must be a first

Fig: 9.

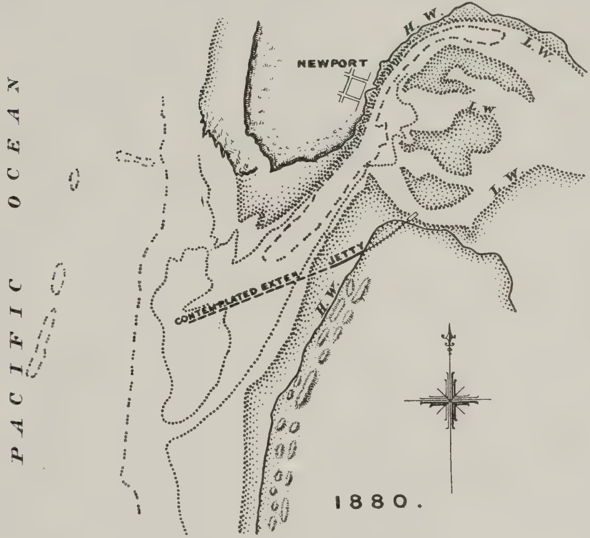
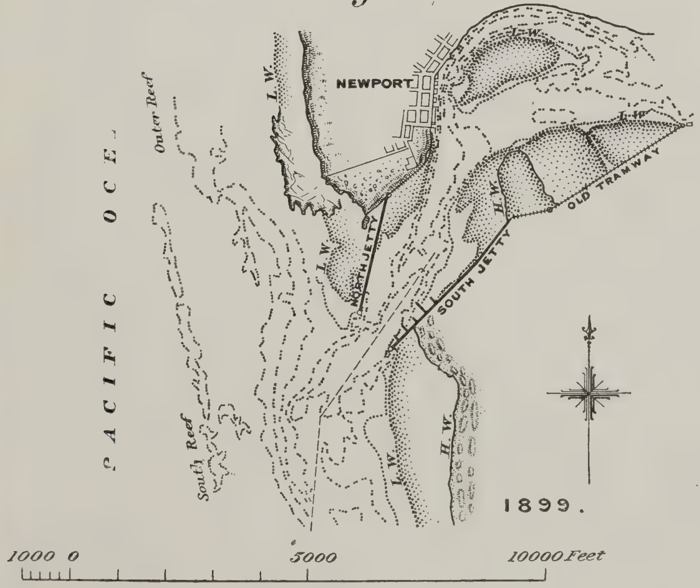


Fig: 10.



Entrance to Yaquina Bay

consideration; and to facilitate entering the harbor during bad weather, this jetty and the permanent channel should be as nearly as practicable in the direction of the prevailing winds which accompany the worst storms. This direction may not always offer the best conditions for impounding the drifting sand; but it is clear that the formeer consideration should be paramount and that the latter should be regarded as of secondary importance. Such a location is not always possible; but a vessel making one of these harbors in a southwest storm should have as nearly as possible a ''fair'' wind and sea, and not be required to enter or depart ''broadside on'' to the wind or waves. On the other hand, the location of the natural ''breakout'' through the bar crest, when this can be ascertained, usually indicates where the best channel depths may be secured. Usually the channel location decided upon is a compromise based on the engineer's judgment.

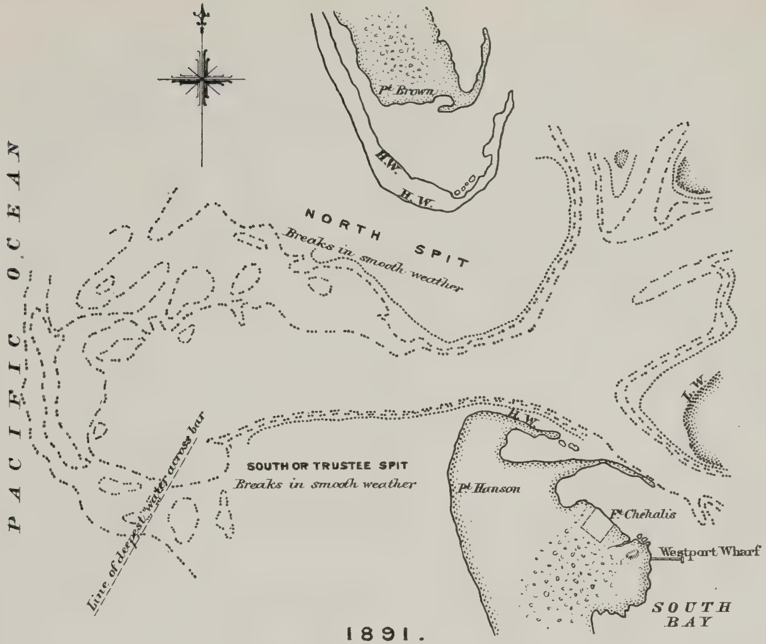
The width apart of the outer ends is another point to be ascertained with much care. This distance must be great enough to admit the tide without material reduction and without producing excessive or dangerous velocities; but still not wide enough to permit shoaling between the jetties or the formation of more than one channel. The width at the gorge is always less than will be found desirable at the bar. By measuring the velocities at ebb and flood tides and determining the area of cross section, the discharge at the gorge may be calculated. The result may be checked by calculating the cubical contents of the tidal prism within the bay, and assuming that it all passes in or out through the entrance on a single tide. From these discharge observations, the proper width of opening between the outer ends of the jetties, the resulting channel depth, and the probable velocities may be approximately calculated. Such results, however, should be taken only as a guide, and not considered conclusive until they have been corroborated by a study of the actual widths, depths, and velocities of the channels elsewhere in the bay.

Another important question is that relating to the elevation of the tops of the jetties. It has been believed by some to be desirable to raise the jetties only to low tide; others have favored mid-tide heights, and others again have advocated high-tide jetties. Besides economy, the main object of leaving the jetties low is to admit the flood tides more readily; the theory being that the main scour is produced in the latter part of the ebb, which is just as well directed by a low jetty. It is significant, too, that nearly all jetties have been built primarily to high-tide levels at their shore ends, to control the littoral drift; but, owing to the battering effect of storms, the outer ends have seldom been kept at their original height, and have subsided in some cases even below low-tide levels. Low jetties are open to the objection that large quantities of sand may wash over them into the protected areas of the bay, and that they do not maintain full control of the currents. The difficulty of maintaining high-tide jetties is very great, and mid-tide jetties have been adopted at the mouth of the Columbia River from motives of economy.

It is believed that the fear of reducing the tidal range within the bay by a reasonable contraction of the entrance is not well founded; experience (at least, at Yaquina Bay) showing that the tidal range may actually be increased by improving the channel entrance.

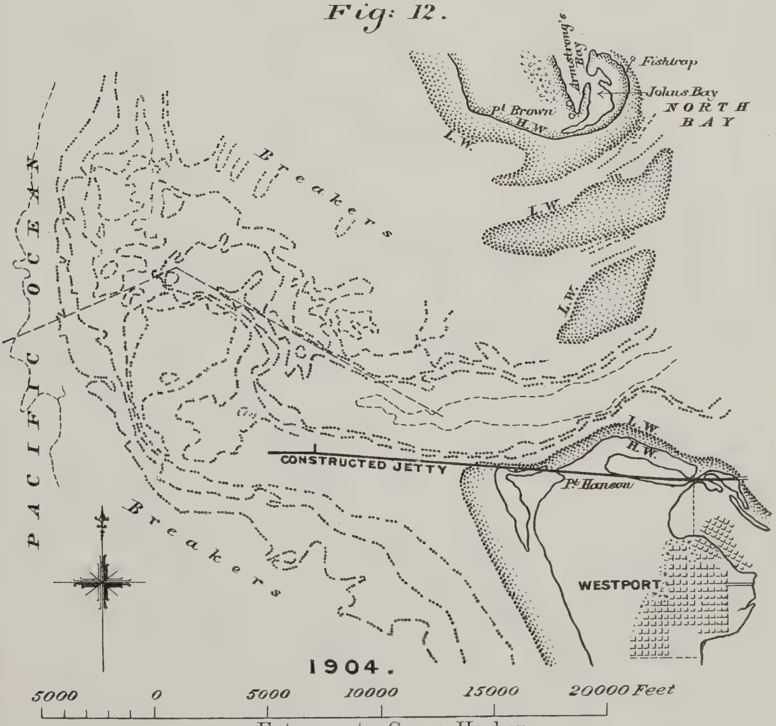
Another principle observed is that the jetties should be prolonged until their outer ends have reached a point where the progress of the bar seaward

Fig: 11.



1891.

Fig: 12.



1904.

Entrance to Grays Harbor

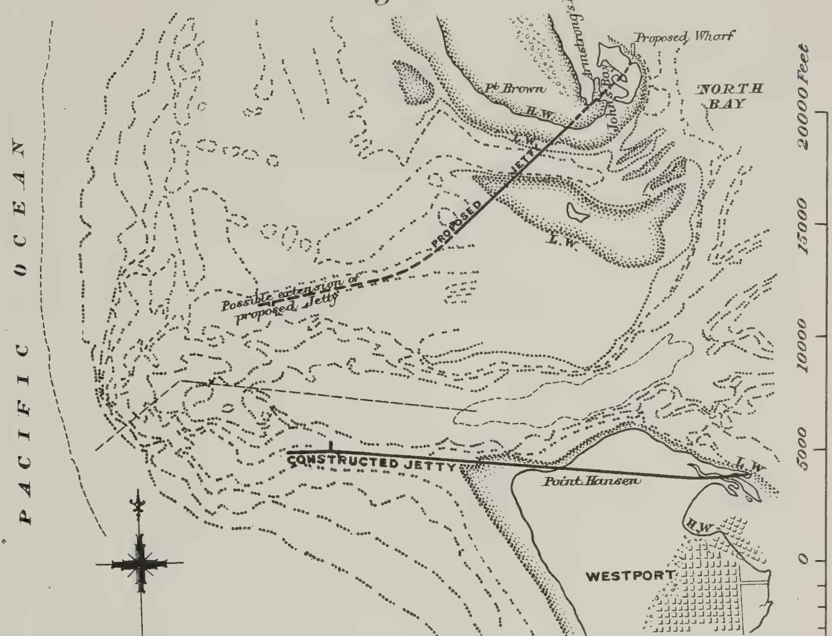
is either entirely overcome or rendered so slow as to make the improvement practically permanent. As the jetties are extended during construction, and the bar yield to the scouring action of the currents, much of the material is carried farther out. Another bar is thus formed in advance of the old one, but having less and less obstructive effect the farther out the jetties are carried. The favorable results secured in this manner may apparently be ascribed to three causes. First, the action of the waves becomes less and less as the water deepens, making it more difficult for them to dislodge sand from the ocean floor; second, as the jetties are prolonged the littoral currents are concentrated more and more across their outer ends, tending to sweep away the sand that might otherwise accumulate; and third, the longer the jetty the longer the time required for filling the angles with sand, and the less the likelihood of the sand wave overlapping the entrance under the influence of the littoral currents.

Experience, however, shows that the best length to adopt can never be very definitely determined in advance, although at Yaquina Bay and Coos Bay it appears that conditions have finally become fairly permanent and satisfactory. It has been found necessary already to prolong the jetty at the Columbia River, and it is probable that the works at Humboldt Bay and at Grays Harbor will also need extending. In general, however, the results indicate that there is probably an economical and suitable length for each locality, although it can not always be foretold with exactness.

The sand at each harbor is not unlimited in quantity, as has been supposed; though its constant circulation at unimproved places may easily produce an effect of practically unlimited supply. It seems, in fact, from the results obtained at some localities, that the larger part of the moving sand may be readily impounded, and thus not only deprived of its injurious tendencies but even made to assist in the work by adding to the stability of the structures. This conclusion is borne out in several ways. Some of the beaches south of the Columbia River have been denuded of their fine sand since the construction of the jetty, leaving the heavy shingle and cobbles exposed. The interference of the jetty with the circulation of the sand about the entrance has caused marked accretions in the angle of the jetty, and this effect has been attended by noticeable erosion elsewhere as the supply was cut off. The comparatively stable condition of the bars at Coos Bay and Yaquina Bay indicates that so much of the moving sand has ben impounded by the harbor works at these places that the quantities still in motion are not ordinarily of much importance. It seems plain that the supply is by no means limitless.

It has further been observed that, even with practically no fresh-water discharge into the harbor, the maximum velocity of the ebb currents materially exceeds that of the floods, giving a net excess in scour seaward. The latter half of the ebb in the ''long runouts'' is the most valuable asset in effecting improvement, as all the creeks, bays, and openings then pour out their contents simultaneously, thus increasing the rate of discharge and the consequent scour. This greater velocity of the ebb flow is perhaps more clearly explained by the fact that the flood operates on a decreasing hydraulic radius, whereas on the ebb the hydraulic radius is increasing. This preponderence of the ebb is very noticeable at all the harbors mentioned.

Fig: 13.



1906.

Entrance to Grays Harbor

Fig: 14.

1891.

Entrance to Humboldt Bay

METHODS OF CONSTRUCTION

Owing to the roughness of the seas, it was found impracticable to employ the ordinary method of placing rock by towing it on barges to the point of delivery and dumping it; and this led to the adoption of overhead tramways, which are on pile bents, the piles being driven by hydraulic jet from an overhanging revolving pile-driver. Under this plan the rock for these dikes and jetties is, in a typical case, quarried within the bay, towed to a wharf, placed on dump cars, carried out on the tramway, and deposited along the jetty line.

In view of the mobile character of the material of the ocean bed, it was a question for many years whether the rock thus placed would not ultimately sink into the sand, causing settlement of the jetty and perhaps its ultimate destruction. In the effort to avoid this, use was made of mattresses composed of brush fascines bound together while slung under the tramway and then sunk in place with rock ballast by slacking off the supporting ropes. Upon this the rock was then dumped, the mattress serving to cut off all currents underneath and thus permit the accretion of sand, which quickly collected in the groin of the jetty. The brush mattress foundation has now been abandoned, except at the shore ends where wave action is severe, in favor of a mattress of spalls and fine rock, which has been found efficacious at several places.

This general method of jetty construction was first undertaken at Yaquina Bay, which is the pioneer work of this character on the Pacific Coast. The locality was a suitable one to begin upon, as the expense would not have been extreme in case of failure, and the prospect of arriving at a satisfactory solution appeared promising. The success of the work justified the adoption of this method of improvement elsewhere, and it has now been applied at Grays Harbor, the mouth of the Columbia River, Coos Bay, the mouth of Coquille River, and Humboldt Bay, and has been suggested for several other localities.

MOUTH OF THE COLUMBIA RIVER

The Columbia River is the largest and most important stream on the Pacific Coast of the United States. It rises in the mountain lakes of British Columbia, flows in a southerly direction and then westward, and empties into the ocean between the States of Washington and Oregon. It is confined between permanent banks down to within about 5 miles of its mouth, where it broadens to a width of 3¼ miles; the estuary having several channels which are more or less permanent. The mouth lies between a high rocky headland on the north, known as Cape Disappointment, and a long, low sand spit on the south called Point Adams. In its upper portions the river has worn its channel through rock, thereby supplying immense quantities of sand; so that in passing downstream, as the slope becomes more moderate, sand bars and sand islands occur in increasing numbers. These islands are constantly changing; wearing away at their heads and building out at their downstream ends.

About the mouth of the river there are many spits, bars, and shoals within and without the entrance. These are composed of fine, easily transported sand, readily agitated in the almost incessant surf about the entrance, and easily shifted in the currents set up by the wind and tide. At the gorge, where the currents are confined to a width of about 3 miles, depths of 60 feet and 70 feet are found; from this point there have been occasionally as many

Fig. 15.

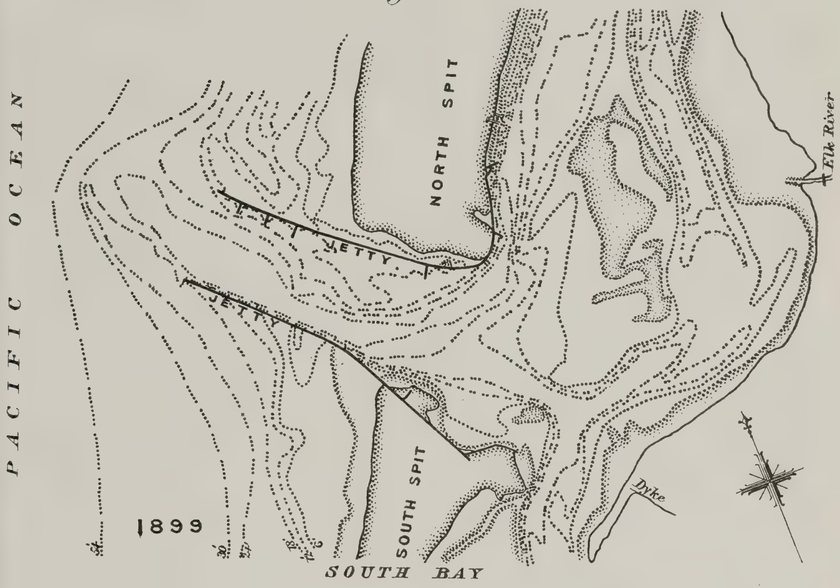
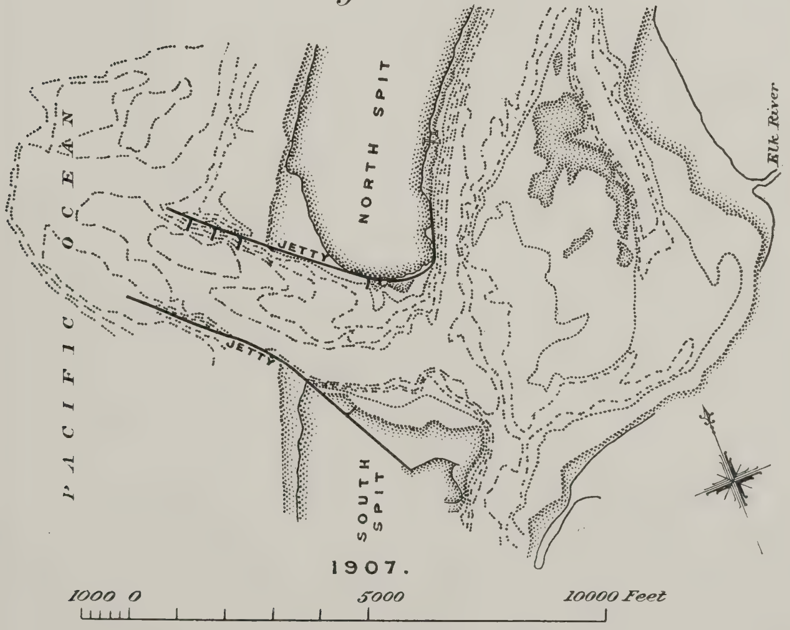


Fig: 16.



Entrance to Humboldt Bay

as three channels, diminishing in depth seaward and variable in direction, location, and depth. (See maps of 1839 and 1874, Figs. 1 and 2.) The entrance is encircled by the usual bar, which lies about 3 miles at sea, and has channel depths varying from time to time within the limits of 10 feet and 25 feet; the entire length of the bar, measured along its crest, being from 10 miles to 12 miles. From Point Adams southward there is a continuous beach 23 miles long, composed mainly of the same fine gray sand. On the north side of the entrance there are also shoals, spits, and sand islands, which were formerly constantly shifting, like the others, in a fairly regular cycle of change.

The fresh water discharge of the river at low stages has been estimated to be from 90,000 to 120,000 cubic feet per second, and at times of great freshets it is probably between 1,000,000 and 1,500,000 cubic feet per second. This flow causes a strong predominance in favor of the ebb current. The high waters are caused by the combined influence of warm rains and melting snows in the mountain ranges, and are believed to carry to the sea large quantities of the fine sand which exists in such profusion along the upper portions of the stream. The Columbia is not ordinarily considered a sediment-bearing stream, being fairly clear at ordinary stages; but after examining the bottom contours about the entrance it seems undeniable that most of the moving sand has been so transported, although the erosion of the headlands and the attrition of the cobbles and shingle along the shores of the ocean have formed an important source.

The average tidal outflow is estimated at 1,200,000 cubic feet per second on a mean tide of 7.4 feet, and 1,500,000 cubic feet per second on maximum tides of 9.5 feet. The maximum rate of the ebb on these tides may be roughly estimated at 2,400,000 and 3,000,000 cubic feet per second, respectively. The currents seaward are very strong off Point Adams, a velocity as high as 4½ knots having been recorded, and 6 having been reported by pilots. The ebb currents have been noticed as far as 150 miles at sea.

The lower portion of the bay is an estuary having an area of about 140 square miles. The depths over the bar, before improvement, varied between 15 feet and 18 feet, increasing occasionally to 25 feet and 27 feet as the channel shifted to the most favorable location. (See Figs. 1 and 2.) The general trend of the sand drift has been noticeably northward, the tendency being to prolong the beach lying south of Point Adams toward the northwest in a long spit known as Clatsop Spit. This drift has always created a pressure on the entrance channels, crowding it gradually to the northward. When the natural channel direction was southwest from the deep water inside of Point Adams the depths in the main channel over the bar were best. But there usually existed at such times a swash channel to the north, over Peacock Spit, which carried part of the discharge and was separated from the main channel by large middle-ground shoals called the "middle sands." (See Fig. 2 for partial illustration.) As the pressure on the channel while in this best location increased in the course of time, due to the drift from the south, the main channel swung northward, scouring off the southerly edge of the middle sands and finally closing the north swash channel, probably with the sand thus gathered. A portion of this mid-ground shoal extended above low water, forming an island known as Sand Island, the presence of which in its most southerly location indicated that the best conditions of outlet depths over the

bar were to be expected. As the channel swung northward, this island also moved northward, finally attaching itself to Peacock Spit at the end of Cape Disappointment. At the same time the depths in the main channel grew less, and its navigability and reliability diminished steadily. By the time the main channel had reached its most northerly location a new swash channel was forming around the end of Point Adams, which in time grew deeper until in its turn it became the main channel, permitting the growth of a new Sand Island, and thus commencing a new cycle of change like that already described.

In 1882 plans were adopted for the improvement of this entrance by the construction of a jetty about 4½ miles long, running northwesterly from Point Adams toward Cape Disappointment, with a view to confine the outflow sufficiently to extend the scouring action of the ebbs through the bar into deep water, and thus produce an outlet having a depth of 30 feet. (See map of 1881, Fig. 3.) As soon as the jetty had been extended across the shoals the northward movement of the channel ceased. While the area in the angle of the jetty was filling the channel remained stationary, and it was not until 1895, when the sand wave overlapped the jetty, that it began again to show indications of a tendency to swing farther northward. This action, however, ceased in 1899.

The plans of the engineers contemplated a jetty 12 feet above mean lower low water at the inner end, sloping to 10 feet above this datum in a distance of 1.8 miles and to 4 feet above this datum at the outer end, the estimated cost being £742,000. The work was completed in 1896 at a cost of less than £400,000, and appeared at that time to be entirely successful. It had, at a little more than one-half of the estimated cost, accomplished the projected results, a channel having been secured that afforded a 30-foot depth over the bar. (See map of 1895, Fig. 4.) In 1896 the depth was 31 feet at the mean of the lower low waters.

The reported completion of the work, however, proved to be premature; the length and height of the jetty not being sufficient to provide for the future maintenance of the favorable depths that had been obtained. Shoaling commenced, and by 1898 the depth had been reduced to 28 feet and the channel had shifted northward into an unstable location. By 1902 the shoaling had progressed to such an extent that there were several channels over the bar, the best showing only 21 feet. (See map of 1902, Fig. 5.)

In view of this deterioration the project for improvement was modified in 1899, and plans were prepared with a view to a permanent increase of channel depth to 40 feet. These plans, which are now being executed, contemplate an extension of the jetty 2½ miles farther seaward, the entire work to be brought up to mid-tide level; this elevation having been adopted mainly on grounds of economy, since a higher general level than this could not be maintained without constant expense. The new project provides also for a north jetty, to be built out from Cape Disappointment over Peacock Spit in case the south jetty should fail to give the expected depth of 40 feet unaided. The distance between the outer ends of the two jetties is laid down as 2 miles. (See map of 1908, Fig. 6.) This width is based upon the need of flat slopes for the accumulations of sand which extend along the sides of the jetties, and which, rather than the enrockment itself, act as the immediate agency in directing the currents.

The cost of the new work has been estimated at £502,000 for the south jetty and £245,000 for the north jetty; making a total of £747,000, which includes £50,000 for a dredger to assist in hastening the scour. Already the new work, which has extended the old jetty about a mile (making it approximately 5½ miles altogether), has had the effect of combining the several channels into one about 6,000 feet wide, and of increasing the depth to 25.5 feet. (See map of 1908, Fig. 6.) The results of the new work will be watched with interest as the construction progresses, and there seems to be little doubt that its completion will fulfil the requirements of the project.

COOS BAY (Figs. 7 and 8).

Coos Bay lies on the coast of Oregon, about 440 miles north of San Francisco. Its entrance from the ocean is between Coos Head on the south, and a long, low sand spit on the north. Southward for several miles to Cape Arago, several rocky ridges extend from the shore into the ocean in a northwesterly direction, and act as ''cut-off'' spurs tending to reduce the effect of storms, to interfere with littoral currents and to oppose the free sand flow. The conditions ordinarily found at the ports along this coast are thus modified in this locality in an important degree.

The north spit is approximately 6 miles long and about 1 mile in average width between the bay and the ocean, the sandy beach of which this is the free end extending northward for over 20 miles. All the currents are tidal, the mean range of the tide being 4.8 feet, although maximum ranges of 10 feet have been observed; the average mean discharge is estimated at 133,000 cubic feet per second. The discharge on the average neap tide is 96,000 cubic feet per second, while that on the maximum tides is probably over 310,000 cubic feet per second. Surface velocities of 4½ miles per hour on low ebb tides have been observed at the entrance.

The entrance to this bay is obstructed by the usual encircling bar, which, in its original condition, ordinarily carried depths of about 9 feet, although occasionally better depths would prevail. It is difficult to follow the action of the sand drift at this port, but it seems probable that its direction is northward and that the building out of the north spit is caused by eddy currents.

The deep-water channel apparently underwent the usual cyclic changes in the course of years, passing from the extreme north to a direction westward from Coos Head. As the southern spit prolonged itself northward the northern spit built out southward, causing an overlapping which made it necessary for vessels to pass broadside on to the sea for long distances before entering the bay.

The original plan of improvement contemplated the construction of two jetties, one to extend westward from Coos Head and the other from the north spit, converging toward the bar, where they were to terminate at a distance apart of 1,500 feet. The length of the north jetty was to be 9,600 feet and of the south jetty 4,200 feet. The purpose of these jetties was to control the sand movement and direct the currents to a selected place on the bar, so that a depth of at least 20 feet at lower low water would be produced and maintained. The location of the channel selected corresponded with that of the ''breakout,'' where the best depths were observed. The total cost was estimated at £498,000.

Construction was commenced in 1891, and the projected depth was obtained in 1894 upon the completion of the north jetty, which was undertaken first. This was apparently not the windward jetty, but in view of the local conditions it was decided to construct it first, in the belief that the moving sand would be more effectively impounded than if the south jetty were built first. The assistance of Cape Arago and the neighboring dikes was relied upon to control to some degree the northward movement of the shifting sand.

The results of the construction of this jetty have been so favorable that the proposed south jetty has never been built, the intention being to postpone this work until its necessity becomes more apparent. Since 1894, when the projected depths were first obtained, favorable conditions have continued to the present time. The cost of the jetty has been £144,000. Considerable difficulty was met with in maintaining the outer end at full height; but the quantities of rock now placed there have been sufficient, even after subsidence, to direct the currents across the bar, thus maintaining the depths required by the project.

This bay may clearly be regarded as an instance of the successful application of the jetty system, the bar depths having been more than double and successfully maintained for upwards of fifteen years at far less cost than was expected.

YAQUINA BAY (Figs. 9 and 10).

Yaquina Bay, on the coast of Oregon, has total area of about 5 square miles. It is the mouth of the Yaquina River, and is a long, narrow estuary having a number of tidal sloughs in addition to the main channel. The fresh water flow into this bay is insignificant except during freshet stages, at which times the addition to the tidal flow acts materially to assist the ebb currents in their scouring action on the bar. These freshets, however, are so infrequent and so irregular in their discharge as to make it undesirable to rely upon them for definite results.

The entrance lies between a rocky headland on the north and a sand spit on the south, and was originally blocked by the usual crescent-shaped bar, over which the depth was seldom more than 7 feet at the mean of the lower low waters. The mean range of the tide is 7 feet, and the extreme range at spring tides about 11 feet. There is a mean tidal discharge of about 32,000 cubic feet per second, and a maximum discharge at spring tides of about 100,000 cubic feet per second.

Before improvement the channel over the bar was variable. The sand drift is northward, and although not observed here with the same clearness as elsewhere, the usual cycle of change has been operative. The entrance is protected by a rocky reef running nearly north and south and lying about a mile off shore, over which the depths are from one to several fathoms. This reef has played an important part in protecting the works constructed for the improvement of the bay and is unquestionably a part of the rocky headland.

The original project for the improvement of this harbor in 1881 provided for the construction of two jetties extending westward from the entrance, one commencing on the high ground on the north side, the other extending out from the sand spit on the south; and converging to a distance apart of about 1,000 feet at their outer ends. A depth of 10 feet over the bar at the mean of the lower low waters was contemplated, or 17 feet at ordinary high tide.

The work was completed in 1895 at a total cost of £138,000; the south jetty being built to a length of 3,500 feet and the north jetty to a length of 2,800 feet. A new channel was obtained through the bar, having depths of 13 feet to 15 feet at mean lower low water and 21 feet to 22 feet at high tide. These depths are considerably in excess of what were expected, and have been maintained for many years at slight expense.

GRAY'S HARBOR (Figs. 11, 12, and 13).

Grays Harbor is a large bay in the western part of the State of Washington. It extends about 17 miles from east to west, with a greatest width from north to south of 14 miles. The greater portion of the bay consists of tide-flats bare at low water and separated by channels having ample depths and areas for anchorage and such purposes of navigation as the commerce of the bay requires. These flats are covered when the tide reaches an elevation of about 5 feet above the mean of the lower low waters. The area of the bay at high tide is about 96 square miles, whereas the low-water area is about 30 square miles, or less than one-third of the high-tide surface. Several streams enter the bay, but the amount of fresh water is small. The extreme range of the tide is over 16 feet, the mean being 8.4 feet. The tidal prism at an average tide gives a mean outflow of 748,000 cubic feet per second, and a maximum tide has a mean discharge of over 1,000,000 cubic feet per second.

The entrance to this bay from the Pacific Ocean lies between two long low sand spits, Point Brown on the north and Point Hanson on the south, the distance between being about 12,000 feet. The entrance is encircled by the usual crescent-shaped bar, and the cyclic changes common to these harbors have been operative here.

The direction of the channel swing and the extension of the south spit northward plainly indicate that the shifting channels over the bar are produced by pressure from the southward. Accordingly, the original project provided for the construction of a high-tide jetty extending out from Point Hanson westward, to impound the moving sand and protect the channel from encroachment. It was hoped that the action of this jetty in cutting off the waste flow to the southward would be ample of itself to maintain 24 feet over the bar at the mean of the lower low waters. It was commenced in 1896 and completed in 1902, though never built to its full projected length. The estimated cost was £200,000, and the actual expenditure has been slightly in excess of that sum.

The contraction secured by the construction of this jetty not having been sufficient to produce the depths desired, a north jetty has been recently undertaken about 9,000 feet long, at an estimated cost of £120,000, to cut off the currents which waste their energy to the northward around Point Brown. The outer ends of the two jetties are to be about 6,000 feet apart. This work is now in progress.

HUMBOLDT BAY (Figs. 14, 15, and 16).

Humboldt Bay lies on the coast of California, about 200 miles north of San Francisco. It is an estuary about 14 miles in length and from 1 mile to 4 miles in width, and is separated from the ocean by two long narrow sand spits from ¼ mile to 1 mile in width, one lying to the north and the other

to the south of the entrance. The beaches and sea bottom are composed of a fine, mobile sand, which has caused great variations in channel location and depth. On the ocean side of these sand pits the beach slopes seaward with a rapid inclination, averaging from 60 feet to 65 feet per mile. This condition is favorable for improvement, but increases the exposure to storms, which in this vicinity are of great violence.

The bay embraces about 24 square miles at high tide, and at low tide its area is 13 square miles. The mean rise of the tide is 4.4 feet. The average discharge through the entrance is estimated at about 105,000 cubic feet per second, and the maximum rate of flow is estimated to be over 200,000 cubic feet per second on the average tide. This discharge is practically all tidal, as there is no fresh-water stream of any size entering this bay. The crescent-shaped bar, sifting entrance, cyclic changes and other usual conditions were all in existence here.

The original plan of improvement contemplated the construction of a single south jetty, which it was expected would fix the channel in position and produce and maintain a depth of at least 20 feet at low water datum. Work on the south jetty was commenced in 1884, with the result that the width of the entrance was increased by scour beyond safe limits. Accordingly in 1890 the project was modified to provide for shore protection and for a north jetty extending out from the north spit and verging toward the south jetty to a point 2,100 feet distant therefrom. As this work proceeded the channel deepened, until in 1899, when the jetties were completed, there existed a depth of 28 feet at the mean of the lower low waters, or more than double the ruling depth before work was commenced; and in 1903 a survey showed a minimum depth of 31 feet.

The length of the south jetty, as constructed, is 8,000 feet, and of the north jetty 7,400 feet. They are rock mounds built on brush mattresses 4 feet thick; the total volume of rock being about 1,148,000 cubic yards, and of brush about 88,000 cubic yards. The mean of many observations shows that on the sea side the rock stands at an average slope of 1 vertical to 2.65 horizontal, whereas on the harbor side the slope is 1 on 2.25. The total cost of the work was £412,000.

Owing, however, to the subsidence of the outer ends of the jetties, and possibly also because they were not extended as far as they should have been in the beginning, shoaling has since taken place; the south jetty having been overlapped by the sand wave. In 1907 the depth in the channel at mean lower low water had fallen to about 22 feet.

It seems plain, upon careful examination, that the new shoaling has not been caused by pushing the old bar seaward, a result that has been feared by many engineers, but rather has arisen from the lack of sufficient storage space in the groin of the south jetty to impound the moving sand. Until this space was filled the favorable effect of the ebb tides was continuous and cumulative; but as soon as the jetty could no longer hold back the sand flow from passing around the end, the bar depths began to deteriorate and the channel to swing northward across the line of the north jetty.

It is probable that an extension of these jetties will be necessary to regain the favorable depths previously obtained. This work is now under consideration by the Government engineers.

The paper is accompanied by twenty-one maps, from which the figures forming Plate I have been selected.

Andrew Atkinson Humphreys

Andrew Atkinson Humphreys (see frontispiece) was born in Philadelphia, November 2, 1810. He entered the United States Military Academy July 1, 1827, and was graduated and commissioned a brevet second lieutenant of artillery July 1, 1831. He served in the artillery at Fort Moultrie, S. C., the Military Academy, in the Cherokee Nation, and at other points until September 30, 1836, when he resigned from the service.

Most of his work in the Army had been in connection with surveying, and upon his resignation he became a civil assistant to Major Bache on the plans for the Brandywine Shoal lighthouse and Crow Shoal breakwater in Delaware Bay. On July 7, 1838, he was reappointed into the Army with the rank of first lieutenant in the Corps of Topographical Engineers, and his first work was on the improvement of Chicago Harbor in 1839, and also on a survey of Oswego Harbor defenses and Whitehall Harbor, N. Y., in the same year. He was an assistant in the Topographical Bureau at Washington, D. C., from 1840 to 1841, and served in the Florida War in 1842. From 1842 till 1844 he was in the Topographical Bureau at Washington, D. C. From 1844 to 1849 he was in charge of survey work in the field. He was promoted to captain, May 31, 1848. In 1849 and 1850 he was engaged on a topographic and hydrographic survey of the delta of the Mississippi River, and from 1850 to 1851 continued in general charge of the work and in the preparation of the now famous ''Humphreys and Abbot's Survey of the Mississippi.'' The work that he done in connection with this survey and the data obtained is yet standard, and the book itself is a classic in hydraulic literature.

The years 1853 and 1854 he spent in Europe examining means for the protection of delta rivers against inundation, but on his return to this country in 1854 was placed in general charge of the exploration and surveys for railroad routes from the Mississippi River to the Pacific Ocean, and of the geographical explorations west of the Mississippi. In addition to this duty, from 1856 to April 5, 1862, he was a member of the Lighthouse Board, and in

the spring of 1860 was a member of a board to revise the program of instruction at the United States Military Academy. He served in the Federal Army throughout the Civil War. On August 6, 1861, he was promoted to Major, Corps of Topographical Engineers, and from December 1, 1861, to March 5, 1862, he was on the staff of General McClellan. In the Peninsula Campaign he acted as chief topographical engineer of the Army of the Potomac, being engaged in the siege of Yorktown and the battle of Williamsburg, and in the operations before Richmond and on the James River. He selected the position and located most of the troops on the Union side at Malvern Hill.

He was appointed colonel and aide-de camp on March 5, 1862, and brigadier-general of volunteers April 28, 1862. In September, 1862, he was placed in command of a division of new troops at Washington, and served in the Maryland Campaign with the Army of the Potomac from September to November, 1862, which included the battles of Frederick and Antietam, and remained with that army through the battles of Fredericksburg and Chancellorsville. He was made brevet colonel, U. S. Army, December 13, 1862, "for gallant and meritorious services at the battle of Fredericksburg, Va.," and was promoted to lieutenant-colonel, Corps of Engineers, March 3, 1863.

He served with the Army of the Potomac through the Gettysburg Campaign and was appointed chief of staff of the army under General Meade July 8, 1863, and major-general, U. S. Volunteers, on the same day. He continued as chief of staff of the Army of the Potomac through the campaign of 1864. On the 26th of November, 1864, he was assigned to command of the Second Corps and continued in that command to the end of the war.

After the close of the war he was assigned to command of the District of Pennsylvania in the Middle Department from July 28 to December 9, 1865, and then returned to duty with the Corps of Engineers. He was engaged on examination of the levees of the Mississippi until August 8, 1866, when he was promoted to Brigadier-General and Chief of Engineers, U. S. Army, in which position he served until July 3, 1879, when he was retired from active service. He was appointed brevet brigadier-general, United States Army, on March 13, 1865, "for gallant and meritorious service at the Battle of Gettysburg, Pa.," and brevet major-general, U. S. Army, on the same date for the same service at Sailors Creek, Va. In addition to his famous report on the Mississippi River,

General Humphreys wrote "The Virginia Campaigns of '64-'65," and "From Gettysburg to Rapidan." Anyone who has read his history of the Virginian campaign must necessarily measure its writer by his impressions gained from that book, and one always reads it with a feeling of regret that all history can not be written in the same way.

General Humphreys was a member of the American Philosophical Society, of the American Academy of Arts and Sciences, one of the incorporators of The National Academy of Sciences, an LL. D. of Harvard University, and an honorary member of the Royal Imperial Geographical Institute of Vienna, and of the Royal Institute of Science and Art of Lombardy, Milan, Italy. He died at Washington, D. C., December 27, 1883.

ADDITIONAL DISCUSSION

A CIVILIAN'S SUGGESTIONS FOR A TECHNICAL RESERVE FOR THE ARMY*

Dr. C. P. STEINMETZ
Consulting Engineer, General Electric Company

I have read with great interest Mr. C. D. Haskins' address on the establishment of a technical reserve, but find it difficult to add anything to the discussion, as Mr. Haskins has treated the subject so exhaustively that to any intelligent American who reads his address the matter must appear obvious and requiring no further discussion, and we can only wonder that nothing has been done before in this direction. This is explained by our national tendency: we are all so occupied with our private interests that we neglect the public interests until it is too late, and we have to pay the penalty, as was the case in the Civil War, in the Spanish War, etc.

War has long ceased to be a question of patriotism and bravery alone; and an army of patriotic heroes, untrained and unorganized, without an efficient engineering staff, would be a mob, which had no more chance of success than the fanatic followers of the Mahdi against a modern army, and, worse than that, against disease.

War has become an engineering problem, requiring the highest class of engineering skill and training, civil and military, and this can not be acquired on short notice. It is true, engineering skill, without patriotism and bravery, is of no value either, but this we do not need to fear; but when an emergency arises, there will always be enough patriots—including those who now talk arbitration and internal peace. There are things which no nation can arbitrate, without abandoning its right of existence.

I believe it would be very desirable if the question of cooperation of engineers in civil life with the engineering problems of the national defense, would be taken up by representatives and committees of the great national engineering societies, and of the large engineering manufacturing companies and the public service and operating companies.

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*This article, by Mr. Caryl D. Haskins, appeared in PROFESSIONAL MEMOIRS, Vol. III, No. 11.

Mr. PAUL HANSEN

M. Am. Soc. C. E., State Sanitary
Engineer of Kentucky

Mr. Haskins' paper is certainly a most interesting one, and if the Government's present policy of maintaining a small Regular Army is to be accepted as a fixed policy it would seem almost imperative that some means must be found for securing a large body of suitably trained officers that may be called upon in time of emergency. Mr. Haskins' suggestions for a technical reserve seem to offer a highly satisfactory solution for the present difficulty, and I can see no reason why they should not work out satisfactorily in practice. There is one thought that occurs to me after reading the paper and the discussions which I did not see specifically stated by any one else, namely, that this technical reserve might be kept up after its establishment by increasing the scope of the military academy at West Point so that a much larger number of men might be educated there in a manner that would equip them for practicing engineering or possibly other professions in civil life, and by giving the students the option of entering the regular service or entering the reserves. The thorough education which is given at both Annapolis and West Point is a matter of common knowledge, and I think it will be conceded that if opportunities such as the above are laid open, it would be possible to secure any number of men by competitive examination, thus insuring a high standard. Should a student elect to enter the reserves it would, of course, be understood that he would be permitted to engage in any form of civil practice for which he is fitted, yet he would be expected to devote a sufficient amount of time to the service to maintain a proper degree of preparedness in time of emergency. Officers obtained as above suggested, it appears to me, would assuredly be thoroughly trained military men, and in addition would have advantageous experience which comes from specialization in civil practice.

I may be very much in error with regard to the above suggestions, yet from the point of view of a non-military man they would seem to have some advantages.

Mr. CARYL D. HASKINS

The nature of the comments which have appeared in regard to the paper which it was recently my privilege to read to the Student Officers of the Engineer School, appear to me to call for only the briefest comment.

I am gratified at the favorable tone which characterizes all of the discussions both from within and without the service. The views expressed by Major Wooten, Corps of Engineers, and by Mr. Paul Hansen alone seem to call for any comment other than an expression of my thanks and appreciation.

I find myself unable to agree with the views expressed by Major

Wooten, for in my conception of the situation I find substantially no similarity between the plan of registration of civilians as possibly suitable officer material and the scheme which I have presented. I am naturally somewhat familiar with the registration plan which is now technically in force, and I venture to gravely doubt its beneficial results. Many civilian engineers of the class from whose cooperation the service could secure the greatest measure of help, either do not know of it at all, or do not regard it with favor. It has been my effort to present (crudely to be sure) a far more comprehensive, and I have ventured to hope, a far more effective scheme—a scheme which should provide instantly a group of amateur officers who would know in advance what was expected of them, what they had to do, to whom to report and how to respond; and above all, a group whose efficiency should be very far above the standard of that of the amateur officers who under past methods have joined the colors in times of emergency.

Especially from the standpoint of the well being of the service, it is my purpose to suggest the creation of a large body of highly influential and highly educated men, who would feel that they were *of the service* and would form a solid supporting influence in civil life.

In regard to Mr. Hansen's comments: The plan which Mr. Hansen suggests commends itself to me highly. Without having had sufficient time to study the suggestions from all points of view, I nevertheless have no hesitation in expressing the opinion that the adoption of such a course would result in the greatest good to the service and the nation. I see but one difficulty, which should, I believe, be weighed with care. It is necessary and important that the sympathy and support of the very many engineering colleges of high standing throughout the country should be secured and maintained solidly for the support of the technical branches of the army. It would be regrettable to adopt any sweeping plan of broad education at a government school, which could be construed as infringing upon the proper activities of the country's great technical schools. It would seem to me, however, to be perfectly feasible to elaborate Mr. Hansen's suggestions along lines which would involve close cooperation and sympathetic intersupport of and with the nation's great colleges.

That some definitely helpful result may follow the discussions which have been had on this entire question of a technical reserve, it is my present plan to take up actively with the great national engineering societies definite initiative work looking toward the achievement of some tangible results at some reasonably early time.

HOW COPENHAGEN WAS FORTIFIED

REMINISCENCES OF

MR. ALFRED J. ROEWADE
Civil Engineer

Did you ever hear of a national naval and military base—in the midst of peace—being fortified by a private association of citizens and the expenses thereof provided by means of a voluntary taxation among the adherents of the policy, these adherents being common, almost exclusively poor people?

Very few readers of these MEMOIRS probably have. Yet it was actually done, against the wishes of the majority of the national parliament, and with—to put it mildly—but lukewarm support of its minority.

This is not fiction, but a simple alignment of historical facts, of events happening within the memory of the present generation. It is a tale that proves how a struggling nation—or rather a cluster of patriots within this—can perform feats otherwise regarded as impossible, if the will, the perseverance and the ability to measure the obstacles beforehand are on hand. A tale which should be heard and preserved among the military records of our parliamentary times, if for no other reason, as a characteristic example of cross currents of popular movements and political party alignments. Useful as an illustration of both and a lesson in relation to national movements under free political institutions, for although this movement defied the parliamentary institutions it was an effect of these, a corrective, and unthinkable under autocratic forms of government. The true base for free political institutions is the responsibility for the government of the nation placed on, and accepted by, the private citizen, the voter. And when the political development has led the government into ruts where party interests are held superior to the national causes, the resort to superior means becomes necessary. We know and admit this, yet as we are prone to hold the popular referendum a panacea for these

political ills, and believe that this in such cases places the responsibility where it belongs, it will be interesting to have a definite case on record, in which the referendum is proved useless because it would only have confirmed the political constellations, would have been harmful instead of helpful to the national cause. For it is to be borne in mind that that part of a free people which is willing to carry the white man's burden by bringing sacrifices for future safety, when no immediate danger threatens, in all ways and everywhere a minority, but a minority which must have some form of representation at the people's forum. It will be illuminating to find this proved by an actual example and a record of the means employed to counteract the unsound political condition.

The Bismarckian idea of a united German Empire and the realization of this idea were the origin of the last sixty years of political and national troubles in Europe, by no means yet concluded. Bismarck was prime minister and leader of the German state of Prussia when he began to carry out his idea, and by military means to force a union of German provinces or states which seemed impossible by political or social means because the national diversities in the several provinces were too far developed. As the Germans on all sides were surrounded by nations which all harbored grudges against them, it was an easy matter to find cause for a threatening display of the sword. In fact, it was far more difficult by diplomatic means to preserve the peace. Prussia was meanwhile the upstart in German national politics, Austria being the recognized leader, and before Bismarck could gain the right of way for his plans the old leader had to be thrown out. Both Austria and Prussia had armies of unknown quality, for peace had reigned for fifty years, ever since the Napoleonic wars, but the opportunity to find out what they were worth appeared in 1863, when the political constellations were utilized by Bismarck to the formation of an alliance between Prussia and Austria, with the avowed purpose of assaulting the weakest of Germany's neighbors, Denmark. This was a safe way of gaining the necessary war experience, for the final result could not there be in doubt, and war he knew was the only means by which national feelings of a higher order could be stirred. Yet it required six months of active war, not without honor to this little enemy, before the seventy millions of Germans had vanquished the two millions of Danes. Prussia having assumed the leading rôle during the war, did what she could to make the Austrian contingent uncomfortable,

and the quarrel thus caused led shortly to the desired result, a breach; and two years later, after the so-called "Thirty Days' War" had Prussia Austria crushed and humilitated at her feet; whereafter Austria was excluded from any interference with Prussian politics and general German affairs. The Prussian army was now in a warlike trim, and filled with the exultation of the victories won it was ready for the next step in the Bismarckian march toward the goal, the German unity, and the war with France resulted, at which the formal establishment of the German Empire was accomplished. After this it was the fourth neighbor's turn, but Russia was wary and dodged successfully the belligerent Germans, until the Japanese undertook the task of humbling that neighbor of Germany. This was no doubt a keen disappointment to Bismarck's successors, for as annexation of land was one of the important aims in these wars they had openly prepared themselves for the annexation of the Baltic provinces of Russia and another chunk of Poland. That the German policy toward the northern neighbor since then has been less aggressive is doubtless due to the simultaneously developed maritime competition with England, and must be regarded as a mere postponement of Bismarck's program, for as the army is Germany's Germanizing element the strain must be maintained.

When war between the two German powers and Denmark broke out, this little nation naturally relied on alliances and assistance from the other leading powers of Europe. But the diplomacy had no difficult task in preventing this. The coalition of Prussia and Austria seemed too formidable to interfere with, and the other powers were too cautious to take any active risks. In concentrating their efforts on a prevention of an annexation of the entire Denmark to Germany, they assumed to have done their duty, and France did later show its friendliness to Denmark by causing a paragraph to be added to the treaty of peace between Prussia and Austria, stipulating that the population of that part of Denmark proper (Schleswig) incorporated into Prussia should by vote decide their nationality. This paragraph, however, remained a dead letter until France was whipped, when it was officially abrogated by Prussia.

That Denmark after the war of 1864 found herself totally crushed, both in spirit and physical development, must be regarded as a matter of course. Deserted by friends and relatives alike, she felt her littleness and impotence most keenly. It may have its

element of satisfaction—pagan as this feeling is—to see the enemies as well as idle friends chastised. Austria's humiliation and expulsion of the "German Bund," France's drubbing—trying as this was to their sympathies; the threatening cloud over Russia and her subsequent defeat in the far east, and now lately the maritime and naval anguish of England, all seem to be direct results of the assault on their country and the too cautious diplomacy at a time when the German aggressions so easily could have been nipped in the bud. Even the separation of Norway and Sweden can be

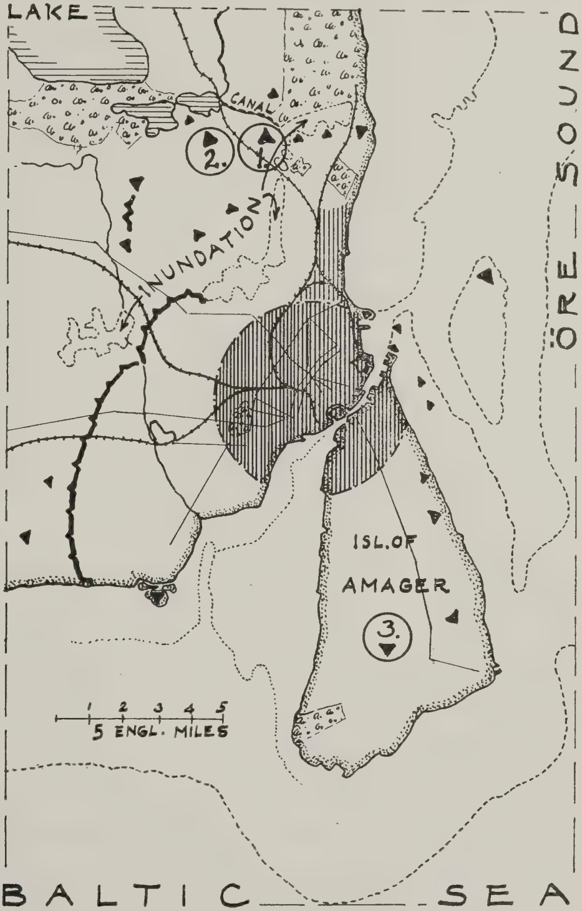

Fig. 1. Sketch map showing the fortification of Copenhagen according to the Government Plan of 1879; 1, 2, and 3 are the Self-taxers' forts; 1 is Garderhoj

dated from a moral setback, the effect of their idleness during the distress of a sister nation. The prospect in regard to what the future has in store is no less awe-inspiring. The giant who fathered the imperial German program knew well enough that all nations have their ups and downs, and that it would be expedient, in order to keep the Germans awake, to have them surrounded by bitter enemies, waiting for the downs that would give them a chance to get even. This he accomplished by annexing provinces of other nationalities and by inaugurating a ceaseless persecution against the non-German element in these provinces. Thus is Germany kept awake and constantly prepared for war, and thus are the other—the neighboring nations—kept on guard, waiting for Ragnarok.

The physical and ethical degradation and subsequent pessimism within the Danish nation, resulting from the defeat, naturally found its expression in the political party alignment and the position taken by the representative bodies to the national cause. Efforts to raise the national spirit to its former plane were met with a ''What is the use?'' and a confinement to the development of the material resources set up as the true program. Yet it nevertheless proved to be a fact that a community which has developed the elements of a true nationality in language, literature, and art, a nation which can look back upon past achievements in the various lines of culture, which takes pride in its past, has a military as well as a civil history, can not in the length of time keep its spirit down, however severe a defeat is felt to have been.

When the first faint pips of a reviving national spirit were heard, it was in form of a call for information in regard to the military situation and the ways to improve this. The military men responded promptly and ably in popular lectures, but this displeased the politicians, who saw an infringement on their prerogatives. The duty of Denmark was, these explained, to maintain a strict neutrality and to keep belligerent tendencies down, in order to avoid suspicions as to the existence of a revengeful spirit. The government was subsequently called upon to curb the officers of the army and navy—a prohibition which could not very well be strictly enforced, as both army and navy officers were members of the legislatures and could not hold information in regard to these matters away from their voters when these desired information—an information which they earnestly wished to give. Meanwhile, it made the officers more cautious than desirable, and the

private citizen, the civilian, had consequently to go direct to the sources and study the military matters, which soon showed its effects.

Thus began the actual civilian movement which should lead to results that must interest any student of rational government. What happened in Denmark may happen anywhere in constitutional states with government by the people, and the twenty years that have passed since the events here related should enable us to review the proceedings without bias.

The regular constitutional ways were tried. *A petition* to government and parliament, asking them to direct their attention to the country's defenseless condition, had been circulated and was delivered at its destination in 1875 with 27,000 signatures. It was but a beginning, and had, as was to be expected, no other effect than to increase the popular interest in the cause.

The next step was of a more serious and practical nature, and consisted in the formation of ''Associations to Promotion of the Defense Movement.'' From a small beginning this grew to cover the whole country with special associations in the several provinces, which by lectures and discussional meetings spread knowledge of and interest in the national cause. These associations soon proved the existence of a widespread sentiment for more active national politics. A commission for the formulation of a military program was appointed by the government, and their report was published in 1879. It contained a plan for the development of army and navy and the fortification of the military base and points securing the communication between the several insular provinces, all proportioned to suit the economical means of the country. While this program remained without effect on the legislature or the political parties, it was enthusiastically adopted by the defense friends as their official program. It was the first documentary evidence of the practicability of their aims and gave them a base or platform for future activity.

In 1881 the associations here mentioned were enabled to publish their own organ, a fortnightly paper named ''Vort Forsvar'' (Our Defenses). This paper was edited with great taste, moderation, and talent as an independent non-political organ for the national cause by Mr. Carl Hall for about twenty years, until the editor's death.

The friends of the defenses thus fortified thought themselves strong enough to repeat the petitional agitation, and ''The Great

Defence-Petition'' was delivered, in 1882, with 107,000 signatures, but had nothing but an irritating effect on the national parliament.

About two years later another but similar means was tried in a proclamation signed by ''The Old Leaders''—the generals from the late war, who called upon their ''Comrades'' from rank and file of those dark days to enlighten the younger people on the conditions during the war of 1864 and the perils of the present outlook. This proclamation was the cause of a good deal of embarrassment to the politicians, but had as little practical effect as the petitions.

The women of the country—the mothers, wives, sisters, and daughters of the vanquished or fallen heroes of 1864—in impatience over the slow progress of the national cause and the politicians' verdict that means could not be provided to carry out the military program, formed a movement of their own, and in order to prove their willingness to make sacrifices quietly collected 80,000 kroner, for which a battery of eight howitzers was purchased and presented to the government. These were the first modern pieces of artillery for land fortifications acquired since the war, and the gift and subsequent display did much to encourage the national spirit.

But while this perfectly loyal development took place, the gravity and fierceness of the political party struggle was continually increased. The Danish parliament consists of two chambers, an upper called the ''Landsthing,'' and a lower the ''Folkething.'' The upper chamber is the conservative branch, its members are elected by the bigger taxpayers, and a number are directly appointed by the king. The lower chamber is elected by popular vote and contains, therefore, the more liberal or radical elements—mostly rurals who were antagonized by the bureaucrats, the nobility and other conservative groups, and kept separated by a chasm of class prejudice, theoretical, though, more than practical. These rural representatives meant, however, that they, as representing the majority of the people—the farmers and the radical urban elements—ought to be at the helm and fill the minister benches. They had the majority in the second chamber, but when both sections of the parliament voted together they were in the minority—a normal and rather international parliamentary condition.

These ''United Leftists,'' as they were called, had a somewhat hard-headed though able leader in Mr. C. Berg, the principal of a navigation school, and his policy was implacable radicalism—not

so much in ideas, though, as in action. His policy was, in the main, expressed in two phrases: the first, ''No money to the defences as long as the ministers are not chosen from our ranks,'' and the other ''Not a penny for any purposes, to this ministry.'' As the annual budget had to pass the lower house first, it was in his power to bury it in committee and prevent its passage. Yet, as the ministry was supported by the king, the upper house and the minority in the lower, his position was nothing but a dangerous bluff, which, with great stubborness, was carried on, jeopardizing the very existence of the country. In some mysterious way Mr Berg had, before this condition appeared, been beguiled to vote for a number of large Krupp cannons for the harbor defenses, which therefore passed, but he never again showed the white feather. There was no doubt a good deal of upper class prejudice against this leader, yet he was intelligent and would not have disgraced the tabouret of the minister-president, and he had probably the numbers of the voters at his back. This proved meanwhile to be a hopeless fight that led to abnormal conditions, riots, and police rule, and when he was arrested at a public meeting for defying the police he met the opportunity of his life—but missed it. If he had then taken a manly stand and told the police the truth, that they interfered with his inalienable rights as a citizen, he would have been the hero of the hour and carried the whole people with him, but instead he insisted on invalidity of vision and hearing and was sentenced to six months' imprisonment. He was somewhat of a martyr after that and carried on his implacable policy, but the charm had gone.

The government, on the other hand, was forced to a rule by parliamentarian obstruction. As no normal budgets were passed but the necessity of keeping the governmental machinery running without stoppage of any sort was apparent, the taxes had to be gathered and the officials paid. In order to preserve a legal form, provisional budgets, intended for passage when normal conditions should be reached, were laid before the upper house as a way to the published records. These were at first confined to the actual running expenses, but gradually—to the satisfaction of the public—increased to embrace the features of the normal budget. The president of the ministry all this time was Mr. Estrup, a landed proprietor of means who sometimes was dubbed the G. O. M. of Denmark, and did not seem to be the man needed under the extraordinary conditions. He talked glibly about reconciliation and

being ready for negotiations and agreements with the obstructive party as if the situation was such as could be smoothed over without a complete surrender. Still, perhaps he had to take this stand, and that the old King Christian actually believed in a conciliatory policy and would have it that way. The whole atmosphere on that side was one of oily diplomacy, confusing to the people, while straight talk, naming things by their right name, was needed. And so things wore on without a ray of light to the impatient national group with its many anxieties.

Sometime in the year 1884 an anonymous call appeared in the columns of ''Vort Forsvar,'' asking friends of the national defences to send their names, as an effort would be made to organize a national subscription. The author of this article responded immediately to this invitation, and found at the first meeting an enthusiastic group of men eager to find out if any new way for action had been discovered. The leader, the originator of the call, was a merchant, Mr. Wm. Nissen, born in that part of Denmark now annexed to Germany, and his idea was to repeat the feat of the women, but on a larger scale, by means of a voluntary but regular taxation by patriotic citizens, thereby to bring a further press to bear upon the government. As it was intolerable to remain idle under the desperate political conditions while the country was gradually going to the dogs, his scheme was agreed to with very little argument and a certain degree of secrecy was agreed upon until a formal board of directors had been organized.

It was, of course, impossible to maintain any real secrecy, for the first and most important work was to find men of national reputation to lead the proposed movement. No easy task, for those most desirable had generally decidedly opposing views. As an example can be named the famous old classic scholar, Professor Madvig, whose Latin grammar is used in the colleges of many countries. He said we had absolutely no juridical right to carry on such a voluntary taxation. We had a government for that, and the fact that they did not do their duty according to our views gave us no right. They alone were responsible, and we could not appropriate the responsibility. And what can you do? Even if you collect money enough to buy new rifles for the army,the government has no right to accept such a gift. The only legal way to acquire rifles for the army is by law passed by the parliament. This was a clear stand, the one upon which the national constitu-

tion was based, and he furthermore emphasized this by publishing a pamphlet which was enthusiastically cheered by the radical press. Our respect for this great man was in no way diminished by his answer, but as his views were contradicted by the recent political development we could not allow ourselves to be influenced by his sentiments. In a short while we had a presentable board of directors, who, at a meeting at the university, selected an acting business committee of seven members to carry out the program as outlined.

It was clear to me from the very first day that the success of this voluntary taxation ought not to be made dependent on the final sum of money we could expect to collect, for it could in any case be merely a fraction of what was needed for the realization of the government's military program. The money we would get in hand should be used in such a way as to force the powers that be into activity, and we should keep this up until the military program was realized. How this should be done was not clear to me at the time, for it was necessary to make an exact account and show the taxpayers value acquired for their money; but things soon came my way, and my six colleagues shared my views, too. It was decided to open the campaign with a mass meeting in the largest theater hall, with a speech by the president of the board of directors, His Excellency Chancellor E. Rosenorn. Here was the natural opportunity to lay down a rule in the right line, and I had no difficulty in persuading the chairman of the business committee, Mr. Nissen, to call on Mr. Rosenorn and ask him in his speech to emphasize the fact that we intended to keep the taxation movement up until the government's military program was realized. He may have thought this rather sanguine, but as it supported the government he gave it in the form we desired, and I took care to have this part of his speech put in big letters in the printed report, afterwards pointing at it as the governing rule for our activity. In order to make it still more clear to the friends of our activity that this view should be taken in earnest, I worked out a savings book system. The calculated expenses of the entire military plan, divided into as many shares as there were individuals in the state, placed on each a share of 33½ kroner, and I let 335 stamps, at 10 ore each, fill the book. Any one filling a book was given a diploma stating that his dues to the fatherland's defence had been paid. The idea was quite successful, and is interesting in a general way

in so far as it was the first time the stamp idea was used outside the postal service.

The chronological order of events as these unfolded themselves in the self-taxer movement were as follows:

The first public proclamation of the aims of the movement followed by an initial list of 2,727 subscribers with a subscribed amount of 250,000 kr. was issued March 28, 1885. It was spread over the country in a number of 350,000 copies.

Immediately after this began the organization of sub-committees, one for each township and each city. Lecturers were procured and pamphlets printed for distribution. Ladies committees for bazars, entertainments, and collections of "preciosa" were later added.

September, 1885, while the subscribed money amounted to 600,000 kr., an agreement was made with the ministry of war to the effect that the self-taxers, as we now were popularly called, should order twenty-five 15 cm. cannons and pay the advance installment, the contract later to be transferred on the war department and the money refunded. This was done six months later, and the purpose of the transaction was to win this much time for the manufacture.

November, 1885, we could announce the gift of land upon which the first of the permanent forts of the land fortification was to be located. This was a topographical eminence named "Garderhoj" (the Guards Hill).

February, 1886, a formal request was made to the king, as the supreme commander of the defensive forces, if he regarded it as desirable that the self-taxers should build a permanent fort at the Garderhoj with the provision that as soon as finished or needed by the war department it should be surrendered to this. Three weeks after, we had the affirmative answer, and thereby was the self-taxers juridical position to the government and the nation acknowledged and fixed.

March 27, 1886, when the money subscribed amounted to 950,000 kr., the work at Garderhoj was inaugurated with fitting ceremonies, Mr. Nissen moving the first spadeful of soil. The plans for the fort were made by the war department's corps of engineers, and a captain of the corps delegated as superintendent. The work, including bomb-free casemates, armor and arms, went on from that date without céssation and was paid for by the self-taxers.

April, 1886, land was bought for an inundation system, with a connecting canal, which formed part of the fortification. The

money expended on these rather extensive purchases was later paid back by the war department, who by this arrangement saved legislation and condemnation proceedings.

August, 1887, when the subscriptions amounted to 1,200,000 kr., a request was addressed to the war minister asking if there were other points in the line of fortification where we could further the realization of the program. In answer, Minister Balmson pointed out another vulnerable point in the line where the construction work ought to be advanced. The land for this fort was bought, and on September 15, same year, the work was inaugurated with a ceremonial program similar to that for Garderhoj. Some time later the government had money available for this work and released the self-taxers. August 27, 1891, Fort Garderhoj was finished and delivered to the war department.

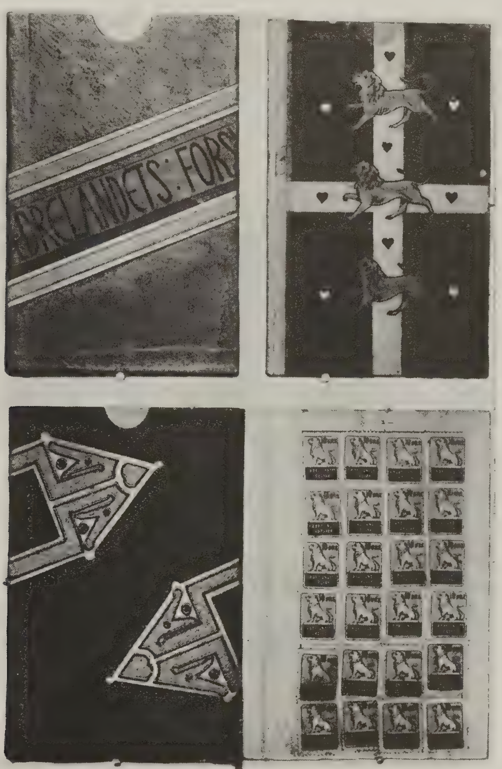

Fig. 2. The Self-taxers' ''Share Book.'' Sheet of stamps shown in lower right-hand corner

As some money was still on hand after the fort had been paid for in full, the land for the southern fort on the island of Amager was purchased and presented to the government.

The total amount of subscriptions and sale of the stamps before mentioned had now reached the two million mark, with 1,500,000 kr. actually paid up—a ridiculously small amount, $405,000—compared to conditions in this country; yet, considering what had been acquired for the money, quite a respectable sum. Should a similar taxation have been levied in this country, it should have brought $25,000,000, if difference in purchasing power were not considered, and, if it were, it would have required an amount of $75,000,000 to comparatively equal the standard set by Denmark in this case.

The movement had borne its fruits. The provisory budgets which still were in fashion had gradually grown bolder, and had, spurred by the self-taxers' example and the public sentiment, provided money for a moderate realization of the military program. The edge had been removed from the anxieties of the national party and the self-taxation movement finally concluded.

This chronological list of the main events in the life of the self-taxation may look like a triumphal march keeping the opposing forces on the run, but it was not so. This movement had an exceedingly hard, difficult, and rough road to travel, and every individual working in its lines had to face an ever-increasing antagonism and boycott. But once in it, there was no turning back. That there is stubborness enough in the Danish character to take a stand in the breach and fight to the end was proved from all sides. Without this quality would the parliamentary obstructionist have been unable to keep up the strife until every particle of their cover was worn to a frazzle. Without this quality would the government have been unable to keep the gay banner of reconciliation waving while at every day that passed such a policy became more and more impractical or impossible. And without this quality would no subscriber have been found and, when found, have been unable to stand against the venom spattered against him from below, till the plighted taxes were paid.

The first serious adversity that met the self-taxers was the accidental destruction by fire of Christiansborg castle in Copenhagen, October, 1884, just in the critical period when the first organization was in the balance. The loss of this historic pile, which housed the

parliament, the supreme court, the royal apartments and the national picture gallery, was a loss to the nation. We realized immediately that this calamity would call forth another and competing national subscription, and so it did. It requires far less independence of character to place one's name on a public list which involves no principles, is participant in no controversy, but simply stamps the donor as a loyal, benevolent citizen, while ours was a fighting venture exposing the subscribers to all sorts of social friction.

The next adversity was the coldness, indifference, and incredulity of the political parties within which we were to find our adherents, a distrust which to a great degree was shared by the government. To proclaim that we intended to keep the movement alive until the military program was realized seemed nothing short of insanity, and it required much hard work before this ice began to melt—it was never quite eliminated. The purchase of artillery mentioned under date of September, 1885, was probably a test to see how we would handle such a proposition, but the promptness and business like way in which it was carried through evidently removed the war department's distrust. To the politicians, however friendly

Fig. 3. The Board of Directors of the Self-taxers on the unfinished Garderhoj fort, 1888

they were personally, we remained the cause of endless trouble, and the sooner we would close up our agitation the better. To keep the movement alive during six consecutive years under these conditions was, therefore, in reality a task which would tax the endurance of the strongest to his limit. No one should therefore wonder at the fact that the working members of the board needed a rest, that after the conclusion of the venture they dropped out of the public view and have ever since shown a reluctance to stir the memories by properly filing the record of the movement.

Thus endeth the Selftaxers' Saga, leaving the political parties in a hypnotized state from which they have not yet fully recovered—a state which is still puzzling political students on this side, because these, as a rule, are unaware of the strife at the bottom of it.

TIMBER FOR PONTON MATERIAL

BY

Capt. F. A. POPE
Corps of Engineers

The following report of Mr. C. W. Zimmerman of the United States Forestry Bureau, temporarily in charge of timber tests at the University of Washington, was made upon tests with Washington red cedar and Alaska yellow cedar to determine their suitability for use for ponton construction. The report is complete in itself so far as comparison of the two species is concerned.

In 1910, similar tests were made by Mr. O. P. M. Goss of the United States Forestry Bureau, Engineer in Timber Tests at the University of Washington. It was the original intention to have these tests all made at the same time, together with tests of white and sugar pine, but this was found to be impossible. It will, therefore, be necessary to use the results of tests made by other authorities to determine the relative qualifications of pine and the timber tested.

Results of the previous tests with a comparison with white pine accompanying the report of Mr. Goss, were given by Lieut. Jos. H. Earle, Corps of Engineers, in No. 11, PROFESSIONAL MEMOIRS, July, 1911. In order to make a comparison with the different kinds of timber it will be necessary to repeat somewhat the information given in Lieutenant Earle's article.

From the average results of the tests made by Mr. Goss and Mr. Zimmerman and various other authorities, Table 1 has been made. In this table the moduli of elasticity and rupture and the elasticity limit are given in pounds per square inch. Under the heading "Authority," "U. W." refers to tests made by Messrs. Goss and Zimmerman; "S" refers to "The Principal Species of Wood, Their Characteristic Properties," by G. H. Snow; "T" refers to Trautwine, 18th edition, 1904; "F. B." refers to the United States Forestry Bureau. The next to the last column, under the heading "MR / Wt" gives the quotient of the modulus of rupture divided by the dry weight per cubic foot, and is inserted to give a

comparison of the strength for equal weights of the different kinds of timber.

Table 1.

Local name	Dry weight pounds per cubic foot	Modulus of elasticity	Modulus of rupture	Elastic limit	MR/Wt.	Authority
Port Orford cedar	28.0	1,730,000	12,600	----------	----	S.
	28.8	1,659,000	8,728	----------	307	U. W.
Upland spruce	26.0	----------	10,400	----------	----	S.
	23.5	1,529,000	6.992	3,400	299	U. W.
Washington red cedar	23.0	1,460,000	10,600	----------	----	S.
	20.0	982,500	5,710	3,633	286	U. W.
Alaska yellow cedar	29.0	1,460,000	11,000	----------	----	S.
	27.0	1,141,000	9,646	----------	352	U. W.
White pine (Eastern)	24.0	1,600,000	8,100	3,300	----	T.
	24.0	1,390,000	7,900	----------	329	F. B.
White pine (Pacific Coast)	24.0	1,350,000	8,600	----------	358	S.
Sugar pine	22.0	1,120,000	8,400	----------	382	S.

It will be noted that the results of the tests made here are quite different from those given by Professor Snow, particularly as to Port Orford and Washington red cedar and upland spruce. While in the tests that were made here, the red cedar used was green, which might cause it to be somewhat weaker than thoroughly seasoned timber, all these results follow out very closely the experience of lumber dealers and users on this coast who use a great deal of cedar and spruce, and for this reason they are probably more to be relied upon than the results given in Professor Snow's book. It is very probable that the tests from which his figures were taken were made on timber from another locality, which would account largely for the great difference in results.

As may be seen from the table, for equal cross section Alaska yellow cedar and Port Orford cedar are very much stronger than white pine, whereas upland spruce is somewhat weaker and Washington red cedar is considerably weaker. For equal weights Alaska yellow cedar is considerably stronger than white pine and Washington red cedar considerably weaker. Upland spruce and Port Orford cedar are somewhat weaker.

From the tests made, it is shown that Port Orford cedar is more brittle than upland spruce, and Alaska yellow cedar is more brittle than Washington red cedar. No comparison was made between Washington red cedar and upland spruce or between any of these timbers and white pine. However, dealers and users of timber who have had a great deal of experience with white pine, spruce, and cedar state that as to brittleness there is not much difference between spruce and white pine, but that cedar is very much more brittle than either.

As it is difficult to secure white pine of either the eastern or western varieties, or sugar pine, it may be necessary to use one of the other varieties for ponton construction in future. Port Orford cedar is practically of little use on account of its great weight, although it is of about the same strength as white pine for the same weight. The same objection applies to Alaska yellow cedar. However, this timber being much stronger than white pine for the same weight, smaller sized timbers might be used. Washington red cedar is much lighter than white pine and very much weaker. However, for equal weights, it is not much weaker. If this timber were used the dimensions of ponton material would have to be increased. As it is undesirable to change the sizes of timbers used, none of the different kinds of cedar tested would be suitable. Persons who have had a great deal of experience with white pine and cedar state that Washington red cedar as regards softness, is about the same as white pine, but is much more variable in quality; that it seasons about as well, but is not quite as easily worked; that it is very much more brittle; that it is more apt to split when nails

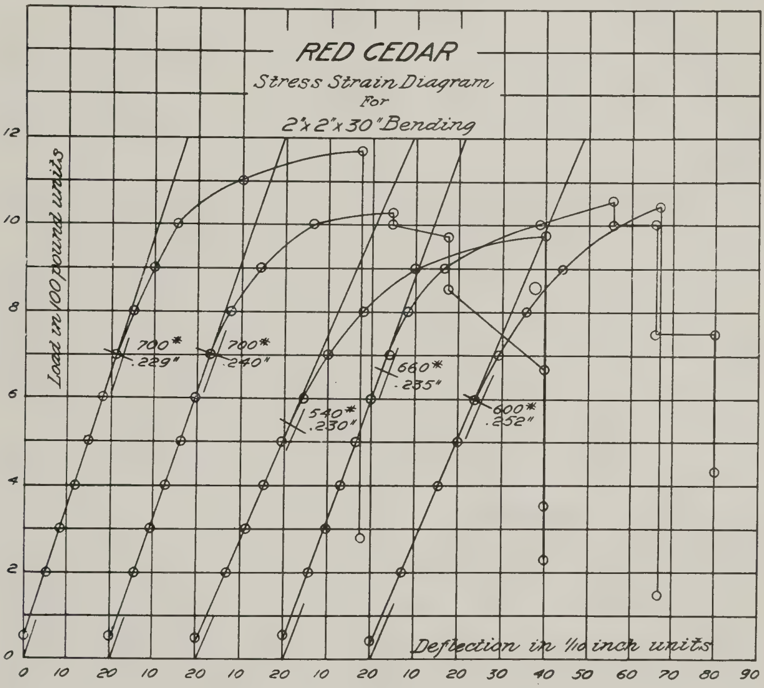

Plate I

are driven into it; that it has much greater durability; that its weight is about the same, but that it is very much weaker; that the shrinkage is about the same.

Washington red cedar can be obtained in pieces suitable for ponton construction; however, it is much more difficult to get than upland spruce. As may be seen from the table, upland spruce is very nearly of the same weight as white pine, and has about the same modulus of elasticity and elastic limit, although its strength is somewhat less than white pine, both for equal cross section and for equal weights.

Washington red cedar is much more variable than upland spruce. As to lasting qualities, spruce does not appear to be as durable as white pine, although nearly so, whereas cedar is much more durable than either.

A record of the tests of chess made from Washington red cedar at the United States Military Academy at West Point, N. Y., is shown on page 461, No. 11 PROFESSIONAL MEMOIRS. The result of these tests was, as a whole, very favorable. The fact that Captain Wooten's tests showed a greater strength in red cedar than the tests made here may be due in part to his having used thoroughly seasoned timber, while the tests made here were on green timber.

The chief objections to Washington red cedar appear to be, the increased size of timbers needed for equal strength, its greater brittleness and variability.

Upland spruce appears to be the nearest to white pine in about every way of any kind of timber available. It has about the same weight, though somewhat weaker. It is, judging from the experience of users in this State, about the same as regards softness, brittleness, durability, and variability. It seasons nearly as well, and is about as easily worked.

In January of this year twenty chess and seven balk were treated with ''Carbolineum'' at Fort Worden, and sent to Vancouver Barracks, Wash., together with an equal number of untreated balk and chess. Very little change in weight was found in the treated timber- but this was no doubt due to the timber being very green, the substitution of ''Carbolineum'' for water not adding greatly to the weight. The timbers were found to check and crack in use, but this was apparently due to their being so green.

Upland spruce is Sitka spruce that is grown in western Washington, particularly around Grays Harbor, at elevations of from 40

or 50 to 1,000 or more feet above sea level. Sitka spruce grows along the coast from Central California to well up into Alaska. It usually extends inland not more than 50 miles. Sitka spruce is sometimes called Tideland spruce, Menzies spruce, Western spruce, or Great Tideland spruce. It is necessary to distinguish, because while Tideland spruce is of the same species as Upland spruce, it is unfit for ponton construction, being full of knots and very coarse and irregular in grain.

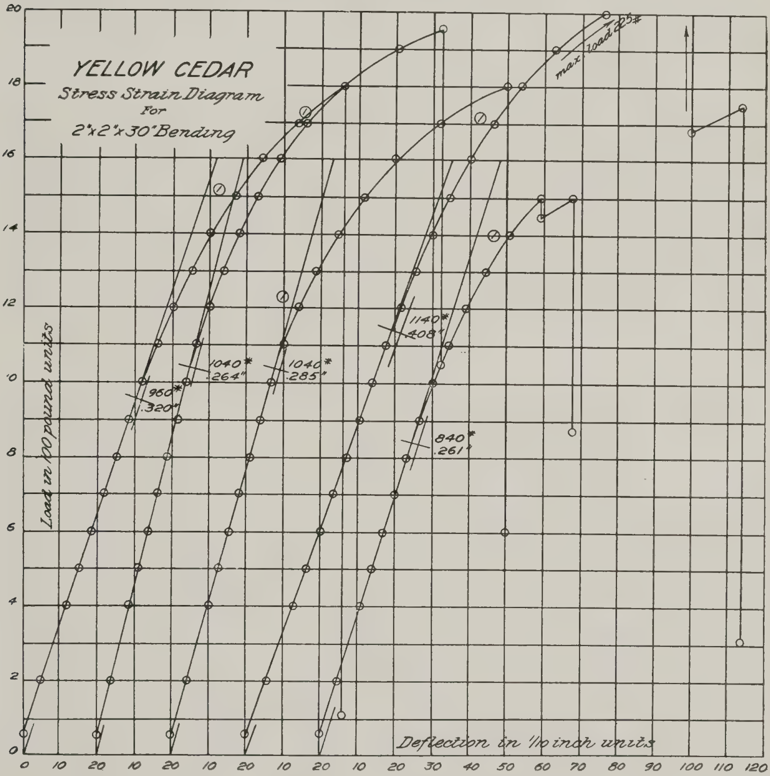

Plate II

Upland spruce is apt to have many knots, but there is no difficulty in getting plenty of good clear timber. Upland spruce has recently been purchased dressed to dimensions for ponton construction, at from $35.00 per thousand up, f. o. b. cars at Grays Harbor towns.

REPORT OF MR. C. W. ZIMMERMAN

UNIVERSITY OF WASHINGTON

COMPARATIVE TESTS OF RED AND YELLOW CEDAR FOR U. S. ENGINEER DEPARTMENT, SEATTLE, OFFICE

SEATTLE, WASH., *March 28, 1911.*

OBJECT

The principle object of these tests was to determine which of the species, yellow cedar or red cedar, was better fitted for ponton bridge construction.

MATERIAL

The material furnished upon which the tests were made, consisted of five pieces of red cedar and two pieces of yellow cedar. The red cedar was received at the laboratory in approximately 28-foot lengths and was cut to 27-foot lengths before being tested. the nominal cross section of the red cedar specimens was 5.00″× 5.00″. The yellow cedar was received in two irregular sized pieces; these pieces were not tested as mains. but were used entirely for minors. The red cedar was green and the yellow cedar air dried when tested.

SPECIMENS

Each main stick of red cedar was tested as a beam and after test a 2 by 2 by 40-inch specimen was cut from the uninjured portion of the beam. This 2 by 2 by 40-inch strip furnished two specimens a 2 by 2 by 30-inch stick for small bending test, and a 2 by 2 by 8-inch stick for test in compression parallel to grain.

All the available minors were taken from the yellow cedar giving the preference to the 2 by 2 by 30-inch specimens

The total number of test specimens secured is as follows:

Main bending tests—red cedar	5
Minor bending tests—red cedar	5
End compression tests—red cedar	5
Minor bending tests—yellow cedar	5
End compression tests—yellow cedar	7
Tests	27

TESTING MAIN BEAMS

Each main beam was supported on a span of 14 feet 8 inches and was placed so that the center came directly under the center of the moving head of the testing machine.

Rocking supports were placed on each arm of the testing machine at a distance of one-half the span from the center. Cast-iron plates, 4 inches wide were centered over these rocking supports and served as bearings for the specimen. The load was applied at the center of the span and was transmitted into the beam through a

rounded bearing block. This block was made of oak and had a radius of curvature of about 16 inches.

A fine wire was stretched along the neutral axis of the beam and supported by nails driven directly over the center of each support. Behind this wire, at the center of the span, a steel scale was fastened firmly to the beam. When the load was applied, the scale descended with the beam and the wire remained stationary. The deflection due to the load applied was read to one one-hundreth of an inch by means of a transit.

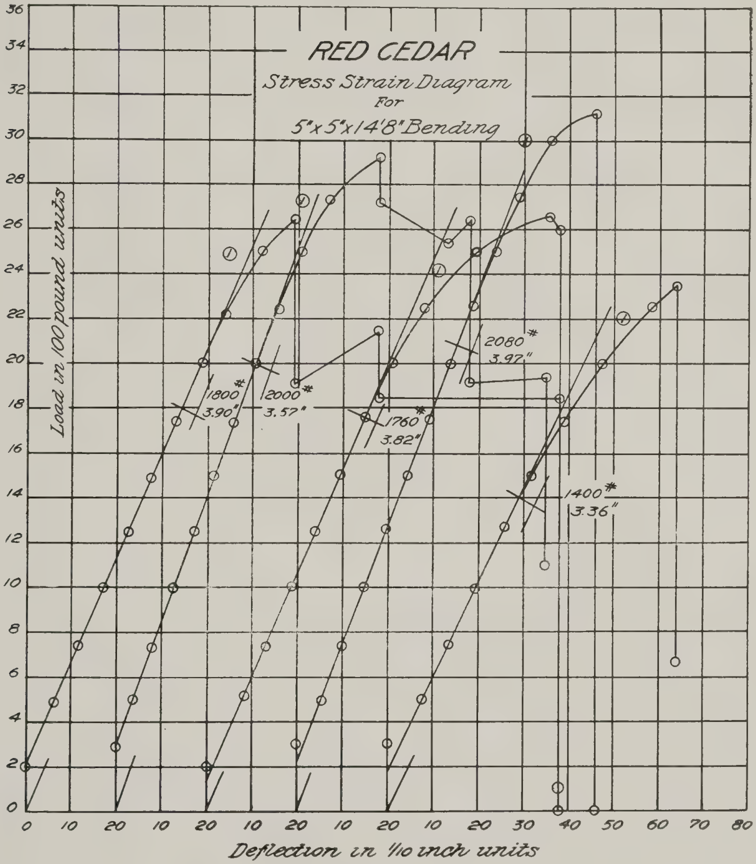

Plate III

The load was applied uniformly and the corresponding deflections for even increments of load were read "on the run." The maximum load sustained was recorded.

SMALL BENDING TESTS

The small bending test was made in a very similar manner to

the large test, except that the deflections were measured by means of a special deflectometer. The principal, however, is just the same as described for the main test and the same general operations were performed in both tests.

COMPRESSION PARALLEL TO GRAIN

This test was a direct end crushing test and maximum load readings were recorded. The specimen was placed on a plate resting on a spherical bearing, to give proper adjustment.

The red and yellow cedar tests were conducted in identically the same manner and on the same machine, so that results are entirely comparable.

All the specimens were weighed immediately before testing. Immediately after test a moisture disc was cut. This disc was weighed at once on a chemical balance, then dried in the drying oven at 100° C. to a constant weight, and reweighed. The moisture percentage was calculated, based on the absolute dry weight.

RESULTS

The results obtained are set forth in tables 2, 3, and 4. Table 2 shows a summary of all main bending and 2 by 2 by 30-inch bending tests. Since no main tests were made on the yellow cedar, the comparisons will have to be drawn from the minor tests. The results of the 5 by 5-inch by 14 foot 8-inch tests on red cedar are simply tabulated. From the minor tests shown on this same table it will be seen that the average oven dry weight for red cedar is 19.5 pounds per cubic foot, while that for yellow cedar is 27.2 pounds, or red cedar is only 71.7 per cent as heavy as yellow cedar. Column 10, table 1, shows red cedar to be only 57.7 per cent as strong as yellow cedar when weight is neglected, basing the comparison on the modulus of rupture. Column 12 shows that the red is only 77.2 per cent as stiff as the yellow cedar, neglecting the difference in the weight of the two woods.

Table 3 shows the results of end compression tests. From this table red cedar is 72.6 per cent as heavy as yellow cedar. This checks approximately the similar figures in table 1. The last column of this table shows the crushing strength of red cedar to be 69.5 per cent of that of yellow cedar.

In order to compensate for the weight of the two species, table 4 was prepared. This table simply gives ratios of the various factors indicated, to the dry weight per cubic foot. Columns 5, 6, 8 and 9 show very favorably for yellow cedar, while column 7 is a little more favorable for red cedar. Columns 7 and 8 indicate that the yellow cedar is much more springy than the red, while the red is a little stiffer than the yellow cedar.

By taking an average of the factors for modulus of rupture and maximum crushing strength, yellow cedar has the advantage of 17.9 per cent.

Table No 2

SUMMARY OF BENDING TESTS

1	2	3	4	5	6	7	8	9	10	11	12◉	13	14
Species	Stick number	Grade	Nominal cross section	Span	Rings per inch	Moisture percent	Weight per cu. ft. *s		Modulus of */□" Rupture	Fiber Str. at */□" el. limit	Modulus of */□" Elasticity	Elastic Resilience */□"	Horizon. shear */□" developed
							As tested	Oven dry					
Red Cedar 5"x5"x14'8"	R-1	Clear	5.00"x5.00"	176"	30.0	32.8	26.4	19.9	5490	3865	1033	.802	77
	R-2	"	" "	176"	27.5	29.2	27.0	20.9	6372	4320	1255	.825	90
	R-3	"	" "	176"	40.5	55.0	31.0	20.0	5680	3770	1025	.772	80
	R-4	"	" "	176"	37.5	24.9	26.3	21.8	6723	4515	1182	.957	95
	R-5	"	" "	176"	9.0	73.2	32.5	18.8	5050	3000	927	.540	71
Average					28.9	43.0	28.6	20.3	5863	3894	1084	.779	83
Maximum					40.5	73.2	32.5	21.8	6723	4515	1255	.957	95
Minimum					9.0	24.9	26.3	18.8	5050	3000	927	.540	71
Red Cedar 2"x2"x30"	R-1-1	Clear	2.00"x2.00"	28"	24.5	85.0	33.9	18.3	6200	3720	816	.719	221
	R-2-1	"	" "	28"	26.5	37.3	27.8	20.2	5360	3660	996	.747	191
	R-3-1	"	" "	28"	45.0	56.9	30.6	19.5	5090	2810	794	.552	183
	R-4-1	"	" "	28"	37.5	96.5	37.6	19.1	5530	3470	964	.692	198
	R-5-1	"	" "	28"	13.5	69.2	34.4	20.3	5600	3200	835	.682	199
Average					29.4	69.0	32.9	19.5	5556	3372	881	.678	198
Maximum					45.0	96.5	37.6	20.3	6200	3720	996	.747	221
Minimum					13.5	37.3	27.8	18.3	5090	2810	794	.552	183
Yellow Cedar 2"x2"x30"	Y-1	Clear	2.00"x2.00"	28"	20.0	16.7	34.5	29.6	9520	5070	1035	1.378	339
	Y-2	"	" "	28"	44.0	17.2	31.1	26.5	10200	5410	1335	1.221	366
	Y-3	"	" "	28"	28.0	16.5	29.5	25.2	9650	5570	1290	1.335	341
	Y-4	"	" "	28"	33.0	16.4	34.7	29.8	11050	5930	950	2.050	395
	Y-5	"	" "	28"	32.0	16.7	28.8	24.7	7810	4370	1095	.974	280
Average					31.4	16.7	31.7	27.2	9646	5270	1141	1.392	344
Maximum					44.0	17.2	34.7	29.8	11050	5930	1335	2.050	395
Minimum					20.0	16.4	28.8	24.7	7810	4370	950	.974	280
Red in percent of Yellow Cedar							103.7	71.7	57.7	63.9	77.2	48.7	57.5

◉ Modulus of elasticity in 1000*units

Table No. 3

SUMMARY OF END COMPRESSION TESTS

Species	Stick number	Grade	Nominal Dimensions		Rings per inch	Moisture percent	Wt. per cu. ft. lbs.		Maximum load	Load in *s/□" ◉
			Cross sect.	Length			As tested	Oven dry		
Red Cedar	R-1-2	Clear	2"x2"	8"	24.5	59.5	33.9	21.2	12950	3270
	R-2-2	"	"	8"	26.5	42.0	27.8	19.6	11800	2937
	R-3-2	"	"	8"	45.7	59.7	30.6	19.2	10350	2562
	R-4-2	"	"	8"	37.5	79.4	37.6	21.0	11125	2770
	R-5-2	"	"	8"	13.5	64.5	34.4	20.9	11470	2892
Average					29.4	61.0	32.9	20.4	11539	2886
Maximum					45.0	79.4	37.6	21.2	12950	3270
Minimum					13.5	42.0	27.8	19.2	10350	2562
Yellow Cedar	Y-6	Clear	2"x2"	8"	33.0	15.9	35.4	30.6	18065	4450
	Y-7	"	"	8"	27.0	15.6	29.1	25.2	17910	4477
	Y-8	"	"	8"	23.0	18.9	36.2	30.5	15070	3730
	Y-9	"	"	8"	26.0	19.8	34.8	29.0	12870	3200
	Y-10	"	"	8"	40.0	16.8	32.1	27.5	19500	4850
	Y-11	"	"	8"	24.0	17.8	29.1	24.7	15125	3710
	Y-12	"	"	8"	36.0	15.2	33.4	29.0	18900	4680
Average					29.9	17.1	32.9	28.1	16777	4157
Maximum					40.0	19.8	36.2	30.6	19500	4850
Minimum					23.0	15.2	29.1	24.7	12870	3200
Red in % of Yellow							105.4	72.6	68.8	69.5

◉ Crushing strength in *s/□"

Table No. 4.

SUMMARY

Ratio Between Various Factors and Dry Weight

	1	2	3	4	5	6	7	8	9	10
Species	Main Bending Tests				Small Bending Tests				Compr. ‖ to grain	Factors for all tests Dry weight
	Modulus of Rapture	Fiber Str at el. limit	Modulus of Elasticity	Elastic Resilience	Modulus of Rapture	Fiber Str. at el. limit	Modulus of Elasticity	Elastic Resilience	Maximum Crushing Strength	
	dry weight	dry weight	dry weight	dry weight	dry weight	dry weight	dry weight	dry weight	dry weight	
Red Cedar	289.0	191.8	53.4	.0384	284.9	172.9	45.4	.0348	141.4	213.1
Yellow Cedar					354.9	193.8	42.0	.0511	147.9	251.4
Yellow Cedar in percent of Red Cedar					124.5	112.1	92.5	146.8	104.6	117.9

CONCLUSIONS

1. Yellow cedar is much heavier than red cedar.

2. For similar tests a much greater strength was developed in yellow cedar than in red cedar.

3. Based on equal weights, yellow cedar showed a much greater strength than red cedar.

4. Based on equal weights, red cedar showed a slightly greater stiffness than yellow cedar.

5. Yellow cedar showed a greater brashness than red cedar. (This was probably due in part to the difference in moisture per cent of the two woods.)

Selected Articles of Engineering Interest

Compiled by Henry E. Haferkorn, Librarian, Engineer School.

In the lists of selected articles published, the publication is referred to by the number preceding its title in the following list. The following abbreviations will be used: I, for illustrated; D, for diagrams.

(1) Annales des Ponts et Chaussees.
(2) American Machinist.
(3) Canadian Engineer.
(4) Canadian Soc. of Engineers. Trans.
(5) Cassier's Magazine.
(6) Cement.
(7) Cement Age.
(8) Cornell Civil Engineer.
(9) Electrical Review (London).
(10) Engineer (London).
(11) Engineering (London).
(12) Engineering-Contracting.
(13) Engineering Magazine.
(14) Engineering News.
(15) Engineering Record.
(16) De Ingenieur (Hague, Holland).
(17) Journal of American Society of Mechanical Engineers.
(18) Journal of Western Society of Engineers.
(19) Journal of Franklin Institute.
(20) Journal of Royal United Service Institution (London).
(21) Proceedings, American Society of Civil Engineers.
(22) Proceedings, Engineers' Club of Philadelphia.
(23) Municipal Engineering.
(24) Municipal Journal and Engineer.
(25) Railway Age Gazette.
(26) Revue Generale des Chemins de Fer (Paris).
(27) Scientific American.
(28) Scientific American Supplement.
(29) Transactions, American Society of Civil Engineers.
(30) Professional Memoirs, Corps of Engineers.
(31) Journal of the Royal Artillery (Woolwich, England).
(32) Royal Engineers' Journal (Chatham, England).
(33) Proceedings Brooklyn Engineers' Club.
(34) Concrete.
(35) Bulletin de la Presse et de la Bibliographie militaires (Brussels).
(36) Internationale Revue ueber die gesamten Armeen und Flotten (German and French). (Dresden)
(37) Revue d'Artillerie (Paris).
(38) Kriegstechnische Zeitschrift (Berlin).
(39) The Contractor.
(40 Cement Era.
(41) Canal Record (Ancon, C. Z.).
(42) Proceedings, Engineers' Society of Western Pennsylvania.
(43) Journal, United States Artillery.
(44) Transactions, Society of Engineers (London).
(45) Journal, Association of Engineering Societies.
(46) United States Naval Institute. Proceedings.
(47) Revue du Genie Militaire (Paris).
(48) La Technique Moderne (Paris).
(49) Electrical World.
(50) Electrical Review (Chicago).
(51) Journal, Military Service Institution
(52) Barge Canal Bulletin.

BLUE-PRINTS.

Automatic printing, washing and drying machine for making blue-prints and direct white prints. (12), June 28, 1911; D. (14), June 29, 1911. I.

BREAKWATERS.

Steel forms for concrete breakwaters or piers. (14), June 29, 1911. D.

CABLEWAYS.

The new high-speed cableways on the Panama Canal. (14), Sept. 14, 1911. I.

CAISSONS.

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El canal de Panama. (Rev. Soc. Cubana Ing.), May, 1911. 12000 words. (Study of the enterprise in general and of the different stages of the work executed or to be done.)—Ex-President Roosevelt on the Panama canal problem. Editorial. (15), July 15, 1911.—The Panama canal. P. F. Martin. (10), June 9, 1911. Supplement. D. I.—The Panama canal. A. Munster. (Pacific N. W. Soc. Engrs., Proceedings), vol. 10, No. 2, July, 1911.—Record of canal work since American occupation. (41), Aug. 16, 1911.—Statement of construction expenditures to June 30, 1911. (41), Aug. 9, 1911, part 2.

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Editorial Notes

An Apology

Our attention has been called to the fact that after sending out for discussion copies of the article entitled "An A-Frame Movable Top to Provide Increased Depth Above Fixed Dams," which appeared in our April-June number, 1911, a change was made in the text without notifying the writers who discussed the original paper.

The third paragraph of the first page was inserted without realizing that it affected the discussion. Inasmuch as Maj. C. A. F. Flagler, of the Corps of Engineers, referred to the lack of such a paragraph in the last paragraph of his discussion, he should have been notified of the change. The insertion of additional matter without due notification to the persons discussing the paper was an oversight and not the practice of the magazine.

Convention of District Engineers

A valuable precedent recently established in the Nashville district has come to our attention, and we venture to recommend similar action in the various engineer districts throughout the country. A convention of all the engineers in the district was held at Nashville in the spring of 1911, and at this convention each engineer submitted an article on the work in which he had been engaged during the past year, or upon an allied subject. The papers were read and discussed, and many of them were sent, for discussion, to engineers outside of the district who had had wide experience along similar lines of work. The results were exceedingly satisfactory and some of the papers submitted, together with discussions thereon, are published in this number of the Memoirs.

This plan provides that the experience of the man in the field shall be recorded at least once a year in a paper written expressly for that purpose, and it is believed that a great deal of field experience is frequently lost under the present system which would be saved and made available if this annual convention idea were gen-

erally carried out. The details of design are too often determined upon by office engineers as distinguished from field engineers, and plans drawn up frequently show the lack of field experience on the part of the designer. At this convention of the district engineers, the field man is given his opportunity to explain points that seem material to him which have not been covered by the plans, or points in which his field experience leads him to believe that an improvement in plans or lay-out could be made, and the result is a combination of the experience and knowledge of the designer who plans the work and of the field man who must carry it into effect.

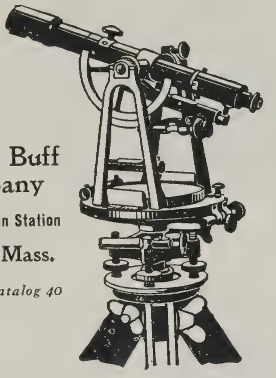
Concerning the Regulation of Rivers

At the risk of calling the attention of our readers to matter with which they are already familiar, we desire to call the attention of our readers who may be engaged upon work of river improvement to the project for the improvement of the French Broad River, by the late Mr. G. T. Nelles, Assistant Engineer, which appeared in House Document No. 616, 56th Congress, 1st session, and afterward without the maps in the Report of the Chief of Engineers for 1900, Vol. V, page 3019, and to the report of Mr. Wm. M. Penniman, Assistant Engineer, on the improvement of the Mississippi River, middle section, by regulation, which appeared in House Document 50, 61st Congress, 1st session, and is Appendix 5 to the Report of the Special Board of Engineers on ''The Survey of the Mississippi River from St. Louis to its Mouth.'' These two articles taken together cover the subject of river regulation very completely and a thorough acquaintance with them will be of the greatest assistance to any one engaged in that work, however familiar he may be with the subject. Both writers discuss the theory of the subject, and to support their points of view give very complete quotations from the best writings on river regulation that have appeared in the last forty years.

Whatever one may believe about the advantages or disadvantages of river regulation as compared with other forms of improvement, there is no question but that it must be followed on certain rivers, and that, whether or not followed on any river, it must be intelligently considered as a possible means of improvement before any final project can be made, and a study of the two articles mentioned will certainly give new ideas and new points of view in connection with any project.

BUFF

Engineering Instruments



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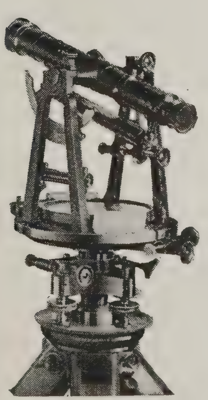

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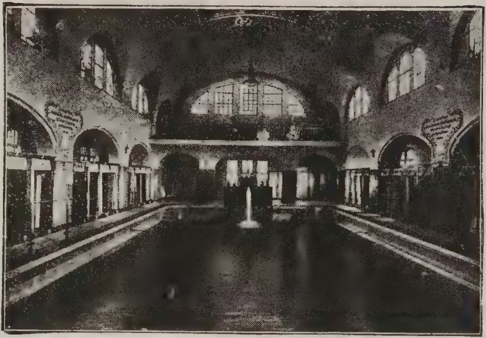

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These studies are both theoretical and practical, and whatever opinion may be held concerning the value of hydraulic equations and the amount of confidence to be placed in the results obtained therefrom, there is not the slightest doubt that a more intelligent, systematic, and probably correct solution can be obtained when the work is planned in the light given by such theoretical discussions than can be obtained by applying "rule of thumb" methods or straight guess work in determining the dimensions to be given to the channel, the location of works, etc. These articles are not of recent date, and it is probable that many of our readers have already studied them. Those who have already seen them will lose nothing by reading them over again, and those who have not read them will certainly find it advantageous to give them a thorough study.

Dredging machinery has improved so rapidly within the last fifteen years, and it offers such cheap and ready mechanical means of removing obstructing bars from rivers and of deepening shoal reaches that many engineers are led to believe apparently that open river improvement can be obtained by removing the accidental obstructions, such as snags, rafts, etc., and by then cutting suitable channels through the existing bars. That this is fallacious will be recognized by even a cursory reading of Mr. Nelles' and Mr. Penniman's articles. To remove the obstructions and deepen the channel by dredging is simply to increase the rapidity of run-off, lower the general low water line and leave the river in little, or probably no, better condition than it originally was. The limits of improvement obtainable by contracting the channel is also discussed, and the reader will finally be convinced that he usually must deal with the subject of a decreased slope if he desires to obtain permanent results in the channel under improvement.

To dredge a new channel through a bar creates at that section a new hydraulic radius R', a new velocity V', and a new area of cross section A'. Using the ordinary meaning of the terms of the formula $V=C\sqrt{RS}$. If the channel for this section then is not, or can not be, so contracted that $V'A'$ is equal to or less than VA, there is no other practical way to prevent lowering the pool above except by decreasing S, the slope. Again, if the bottom is erodible to any appreciable degree the increase in velocity will cause the current to attack the bed and a gradual lowering of the bottom will result, followed necessarily by a lowering of the pool surface above the bar; and to prevent this the bottom must be protected

against erosion. There is no possible escape from these conclusions.

The foregoing remarks should not be understood as advocating improvement of rivers by regulation. They are simply a plea for a thorough study of causes and results, if the policy of regulation has been decided upon. Regulation is an interesting and rather alluring subject for a student of hydraulics, but the relative number of successes and failures in streams whose improvement has been attempted by this means should lead the engineer to a very careful study of the river before he recommends improvement by regulation, and to a complete understanding of the reasons for and the effects of the different elements in his plan if regulation is finally decided upon.

Harbor Facilities

The Engineering News of September 7, 1911, has some very pertinent remarks in regard to the lack of, and necessity for, proper port facilities in the various harbors of the United States, and compares some of our harbors with those in Europe.

That such facilities do not exist has long been known by all those engaged upon the harbor works; and in many cases it almost seems as though the sums spent for improving the channels were largely wasted, inasmuch as the old ramshackle wharves and tumble-down warehouses give no indication that the local authorities desire to avail themselves of the deep water produced by the harbor improvements. There are a few ports to which these remarks do not apply, and since the collection of data which showed the ownership of the lands along the waterfronts of our improved harbors, which was published in the ''Report of the Commissioner of Corporations on the Transportation by Water in the United States,'' there seems to have been a more or less general awakening to the necessity for municipal control, or at least public control, of a fair proportion of the waterfront on improved harbors.

This is not a subject that can be handled in the best manner by the Federal Government, and it will therefore, doubtless, be left to the municipal corporations, or to commercial bodies of such cities who will have to plan, construct, and control the necessary harbor facilities.

The Report of the Chicago Harbor Commission for 1909 would indicate that Chicago, at least, is making an intelligent study of this problem, and intends to plan her port in the light of experience gained from other large ports in various parts of the world.

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